Turbine Generator Vibration Damper System. Vladilen Safonov.

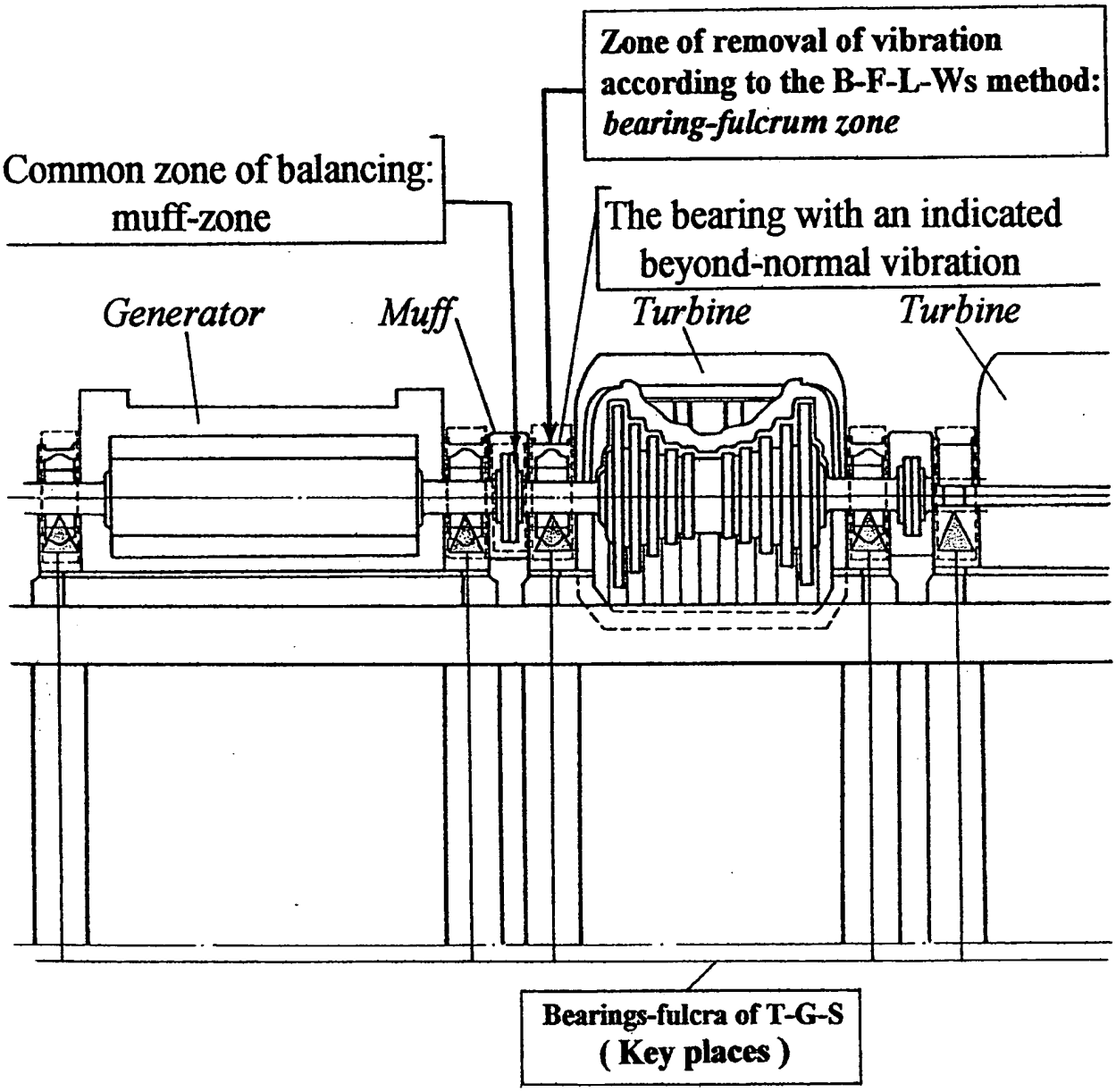


Fig. 1 Zones for application of the process (the method of removal of beyond-normal vibrations at T-G-Ss without stopping their generating electricity / being in operation) - bearings-fulcra zones.

Turbine Generator Vibrati n Damper System. Vladilen Safonov.

I: The B-F-L-Ws to be installed at presently operating T-G-Ss.

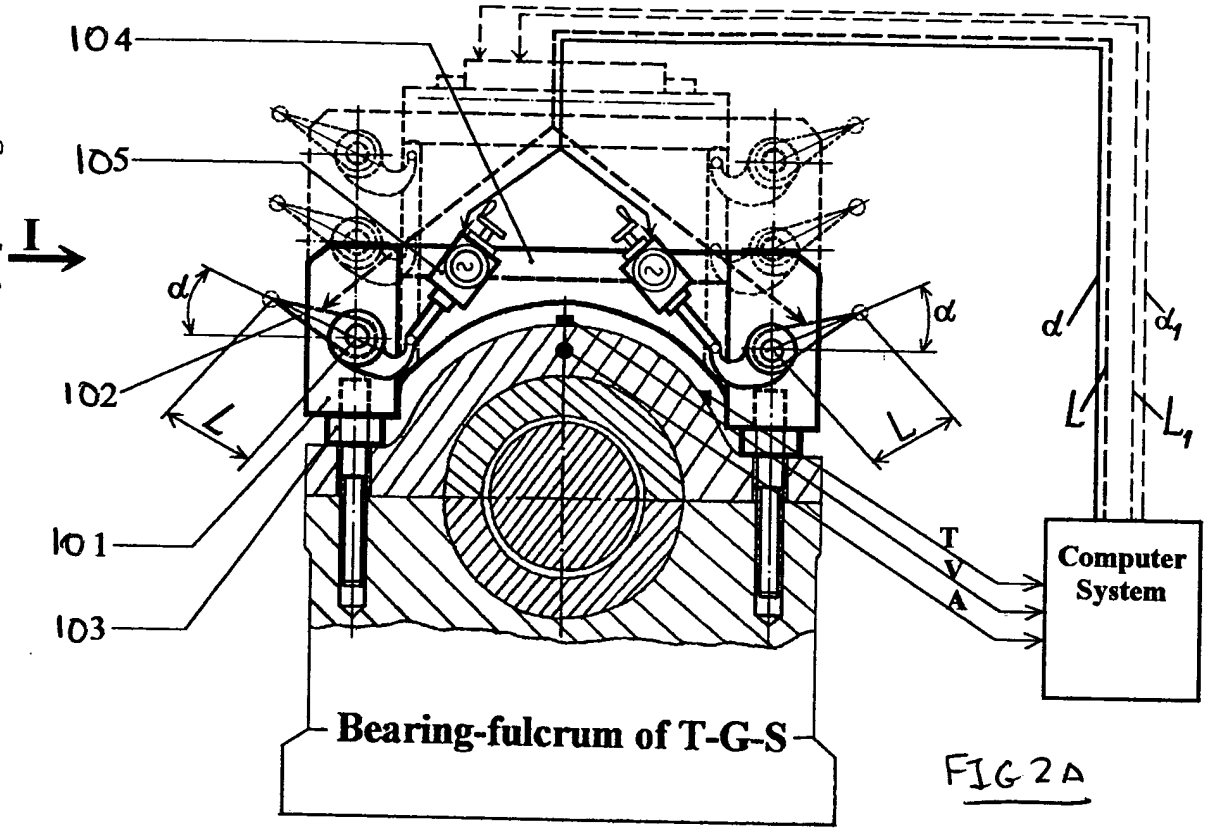


FIG 2A

II: The B-F-L-Ws in a form of specially designed bearing housings in future designed T-G-Ss.

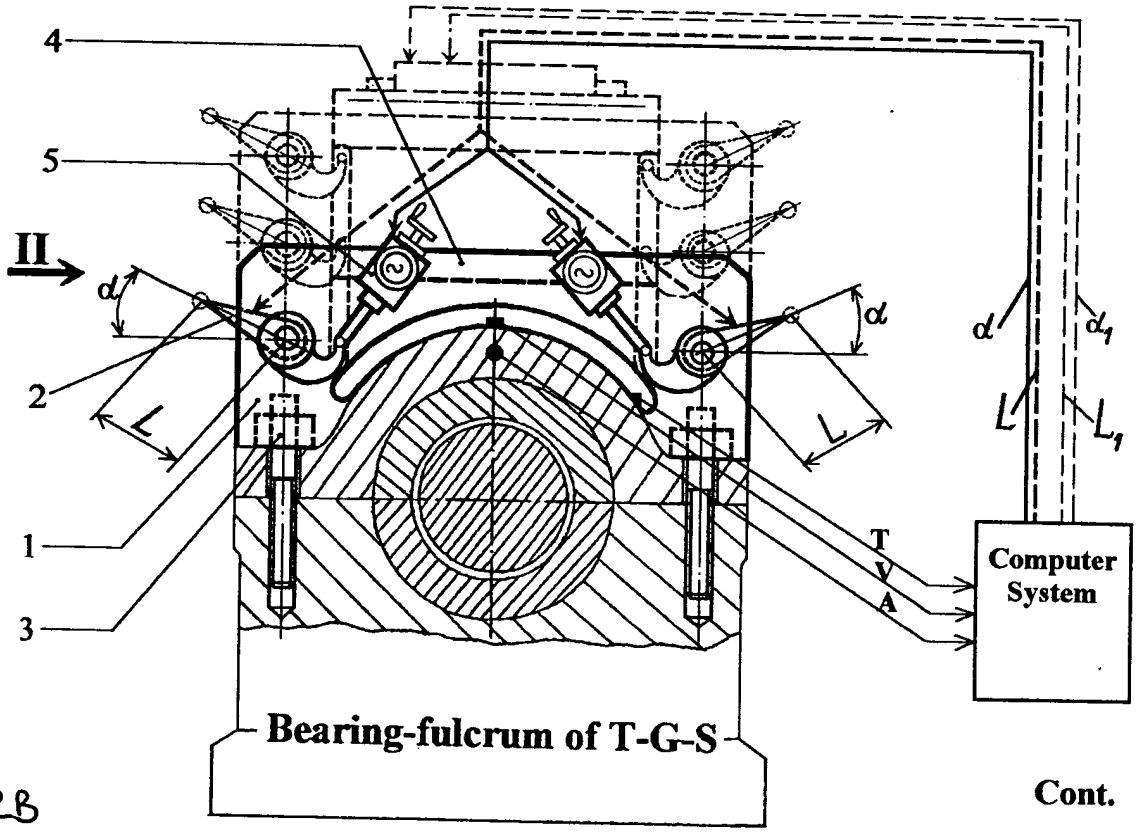
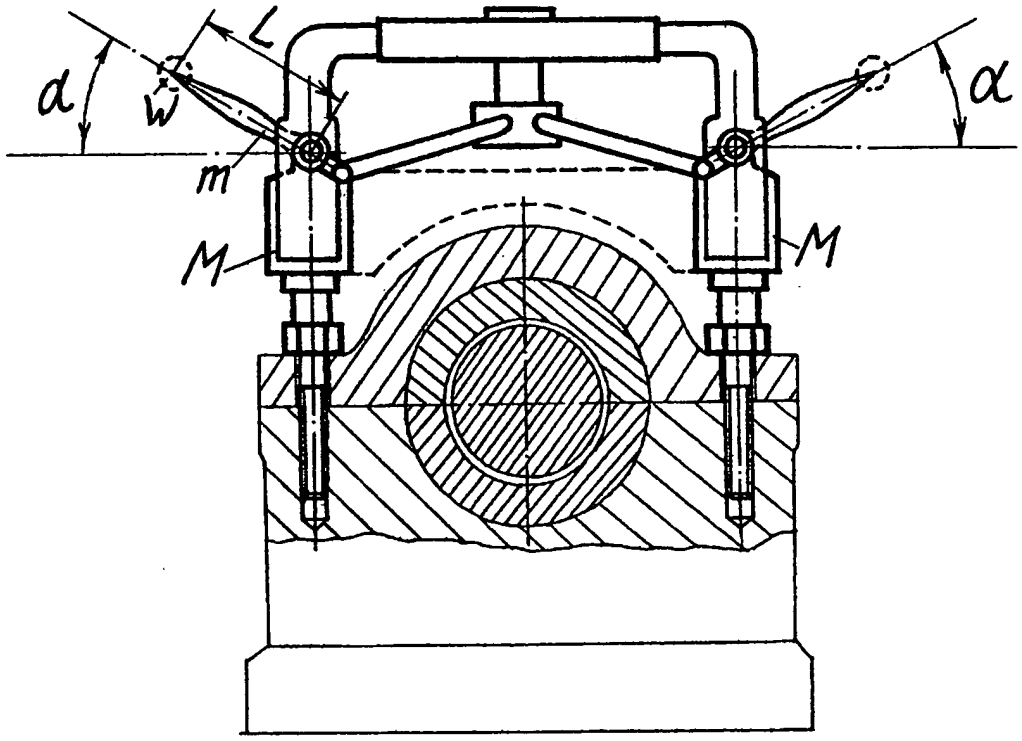


FIG 2B

Cont.

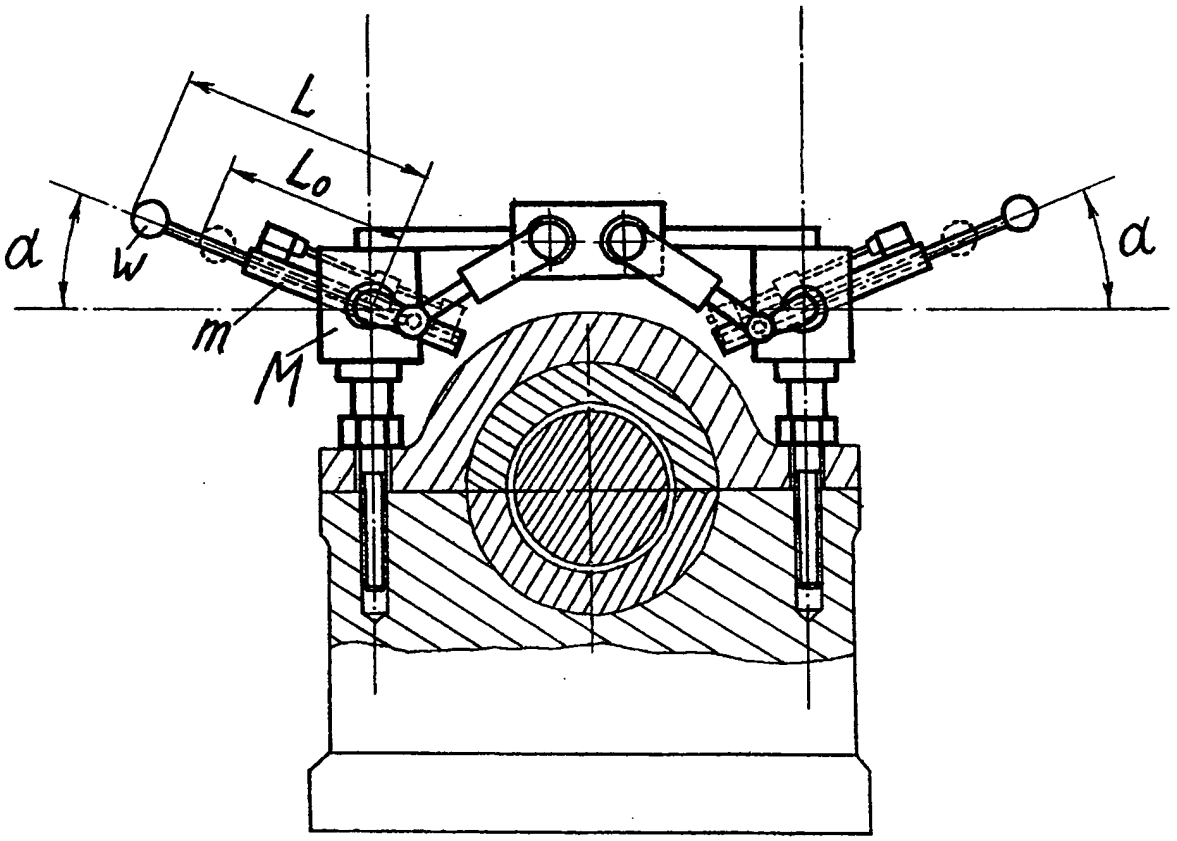
~~Fig. 1a~~ **Turbine Generator Vibration Damper System: Principal scheme of application upon T-G-Ss.**



Bearing-fulcrum of T-G-S

Fig. 3 The B-F-L-Ws for removal of beyond-normal vibrations in wide diapasons.

For the stated M & L(m, w) tuning the system to the vibrations damping is done by changing α.
See text in Specification.



Bearing-fulcrum of T-G-S

Fig. ~~2~~4 The B-F-L-Ws for removal of beyond-normal vibrations in super-wide diapasons.

For the stated M (and m, w) tuning the system to the vibrations damping is done by changing L and α.
See text in Specification.

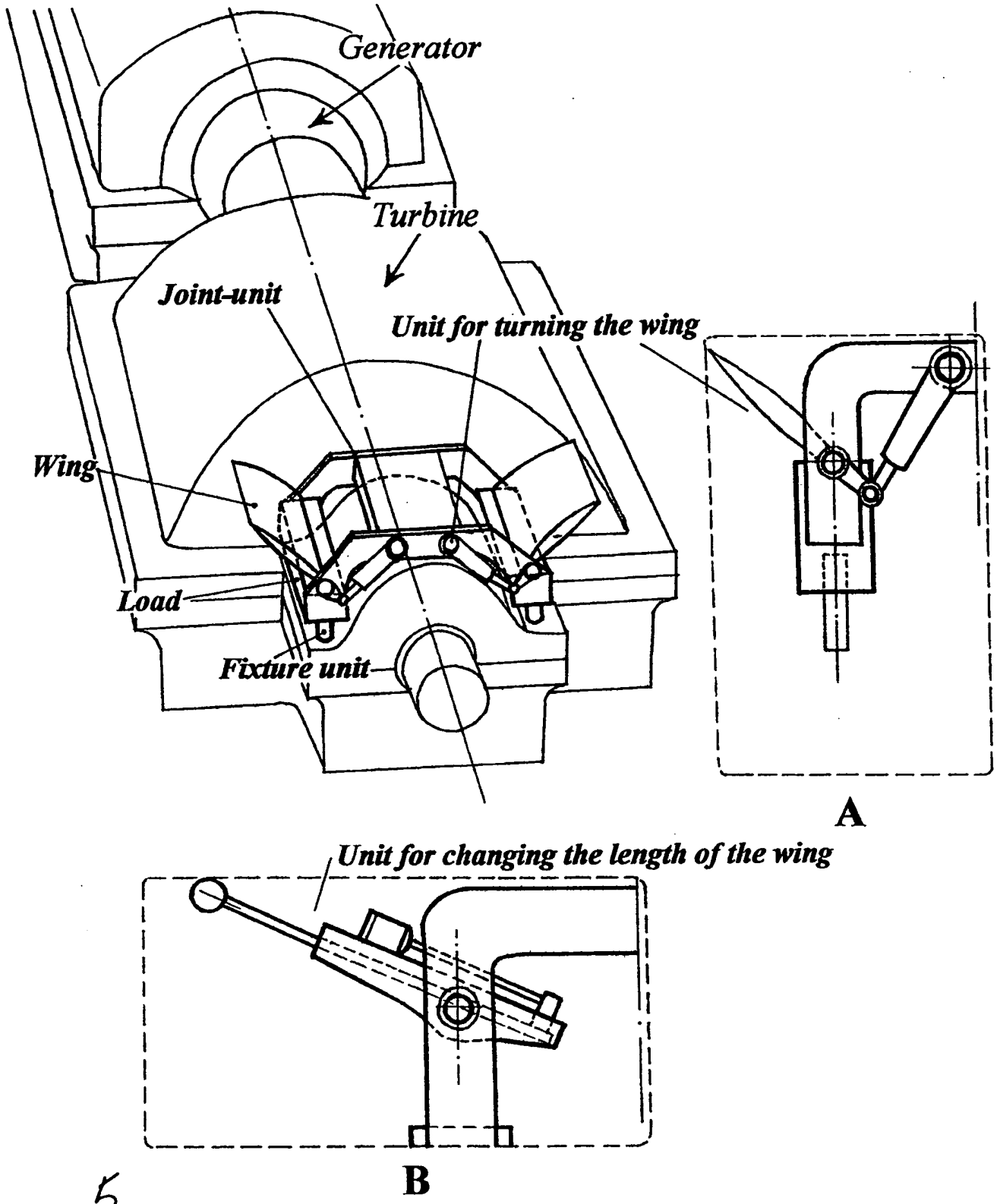


Fig. 5 The main elements of the B-F-L-Ws.

Turbine Generator Vibration Damper System. Vladilen Safonov.

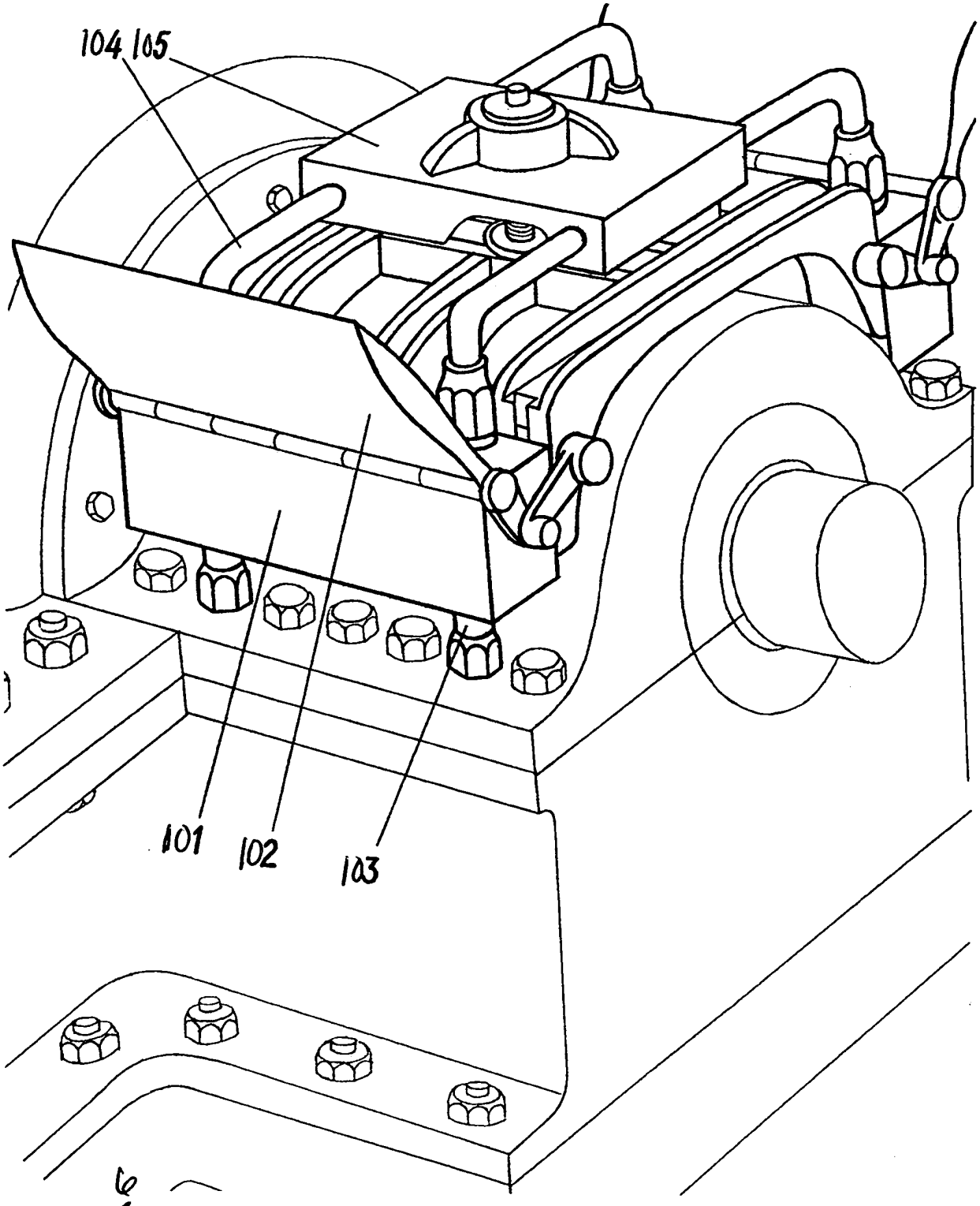


Fig. 3a The B-F-L-Ws for removal of beyond-normal vibrations in wide diapasons (variant). See text in Specification.

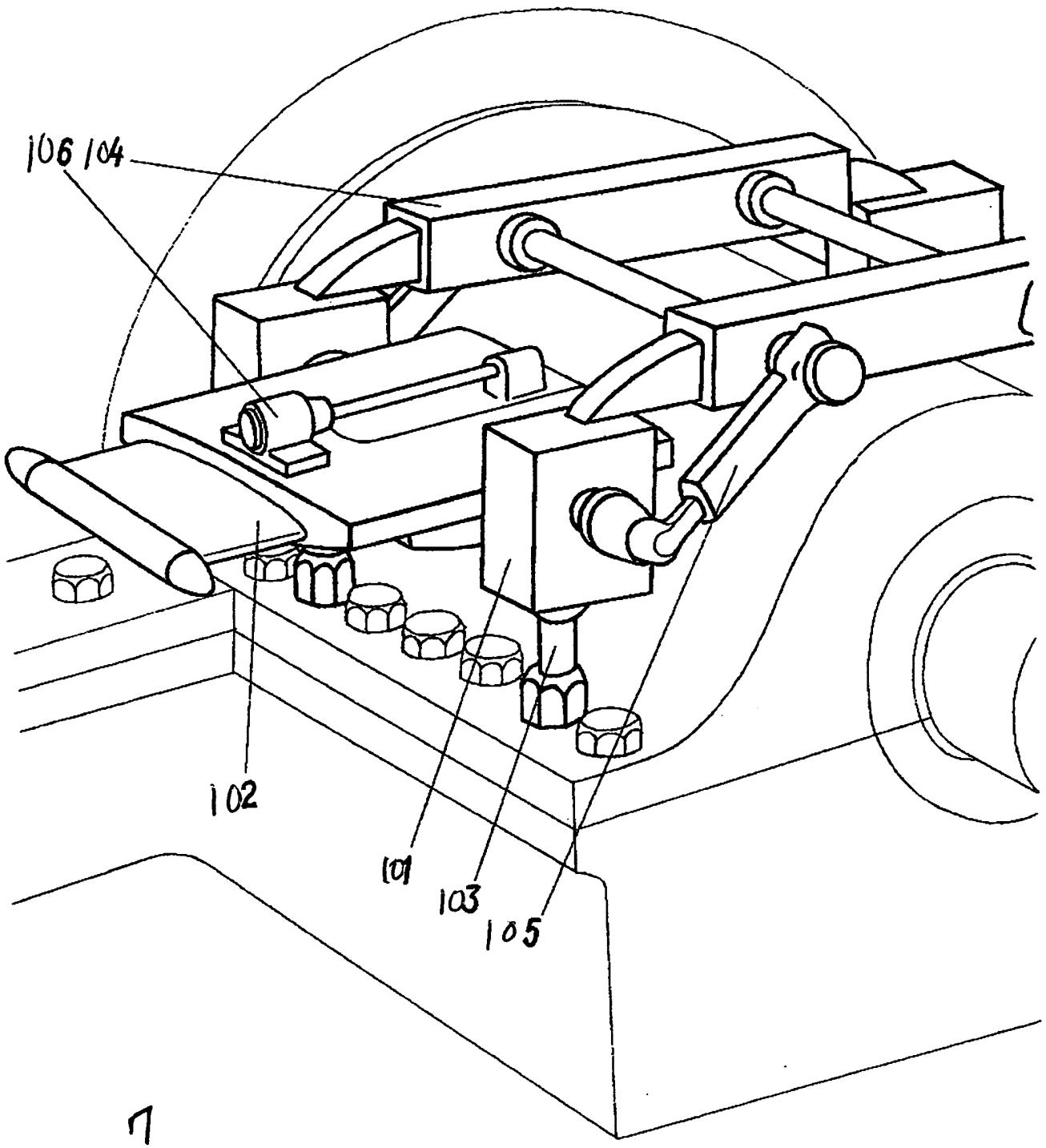


Fig. 3b The B-F-L-Ws for removal of beyond-normal vibrations in super-wide diapasons (variant).
See text in Specification.

Turbine Generator Vibration Damper System. Vladilen Safonov.

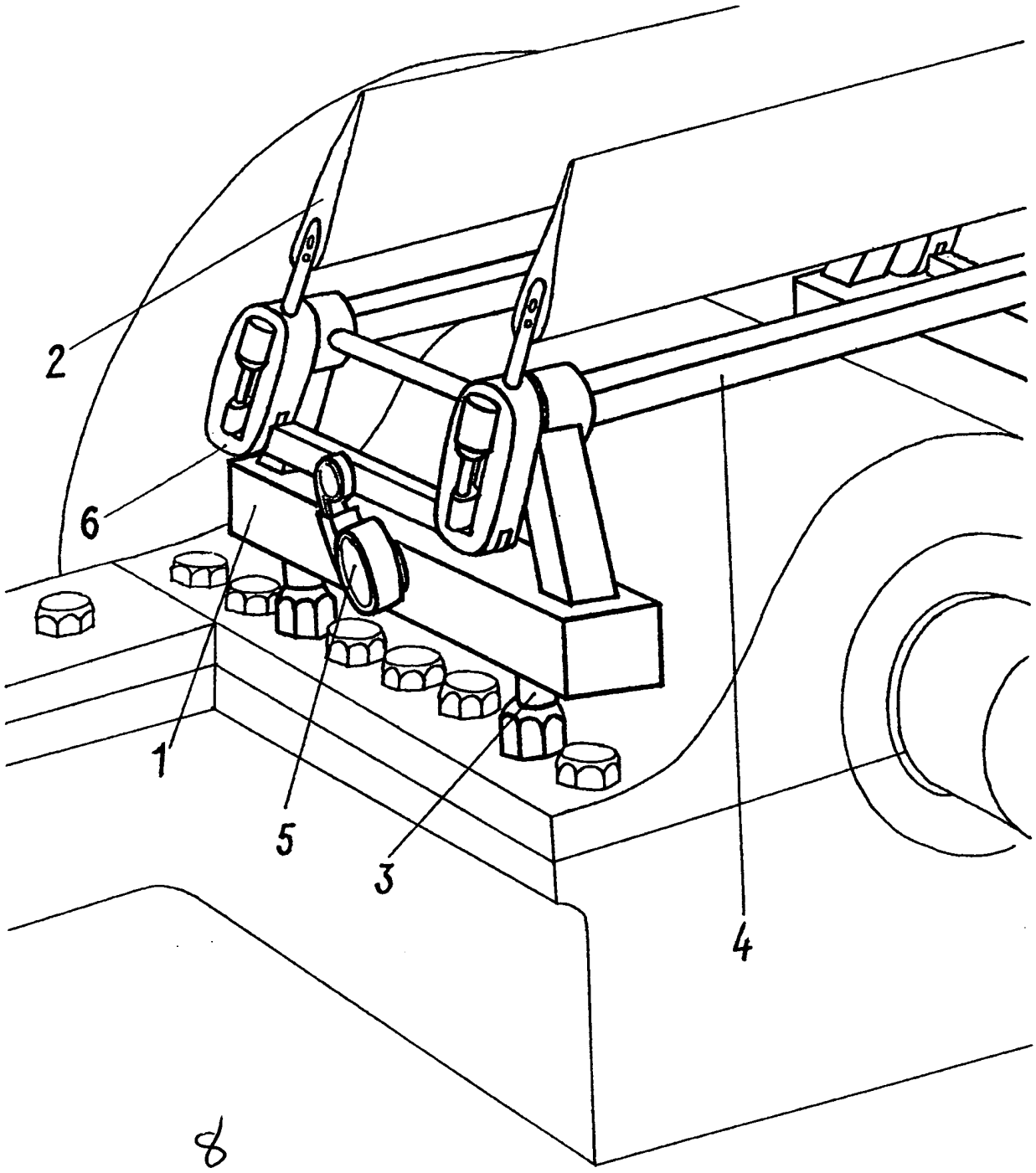


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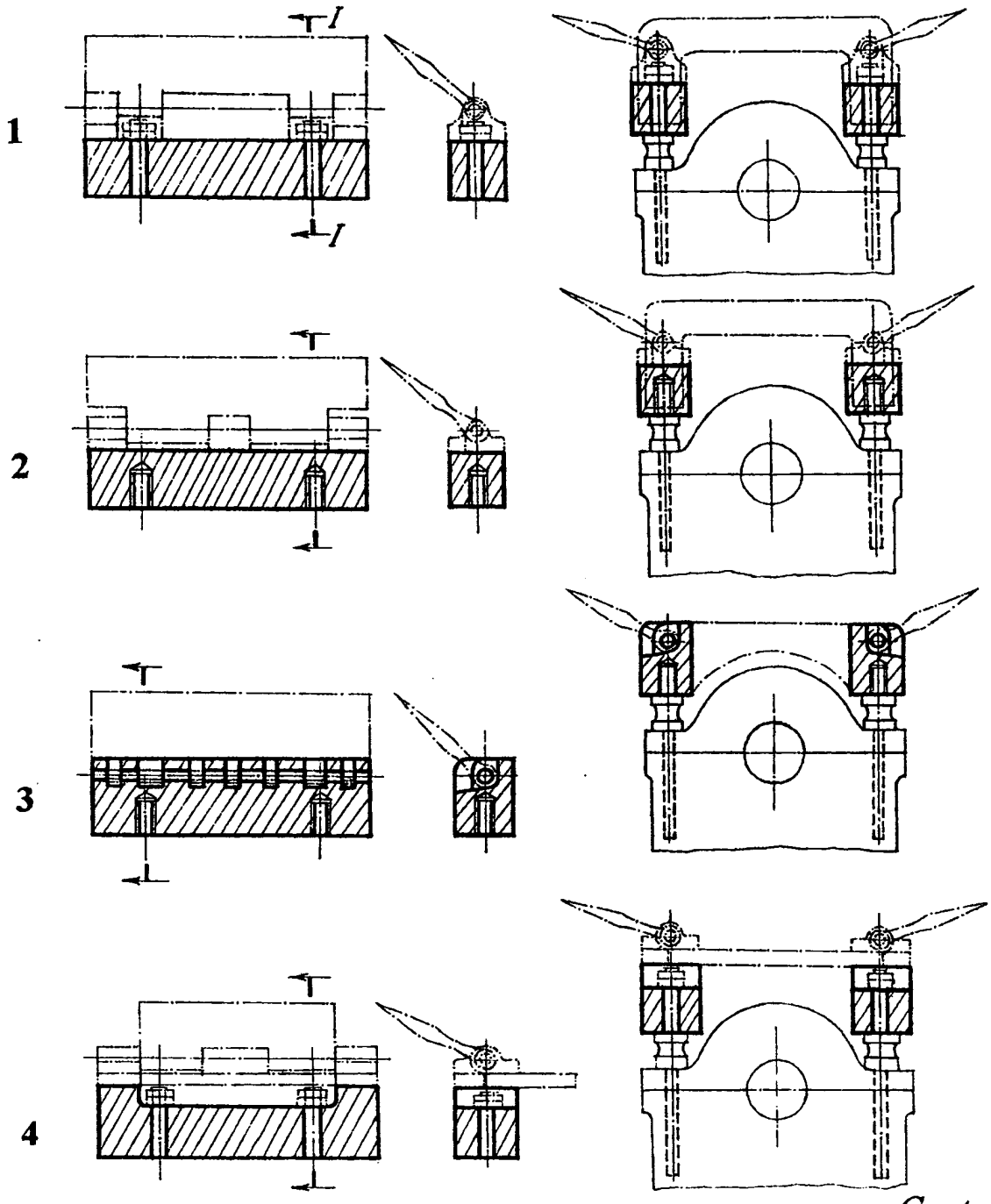
Fig. 3c The B-F-L-Ws for removal of beyond-normal vibrations in super-wide diapasons (variant).
Placement in direction perpendicularly to rotor axis of T-G-S.
See text in Specification.



Cont.

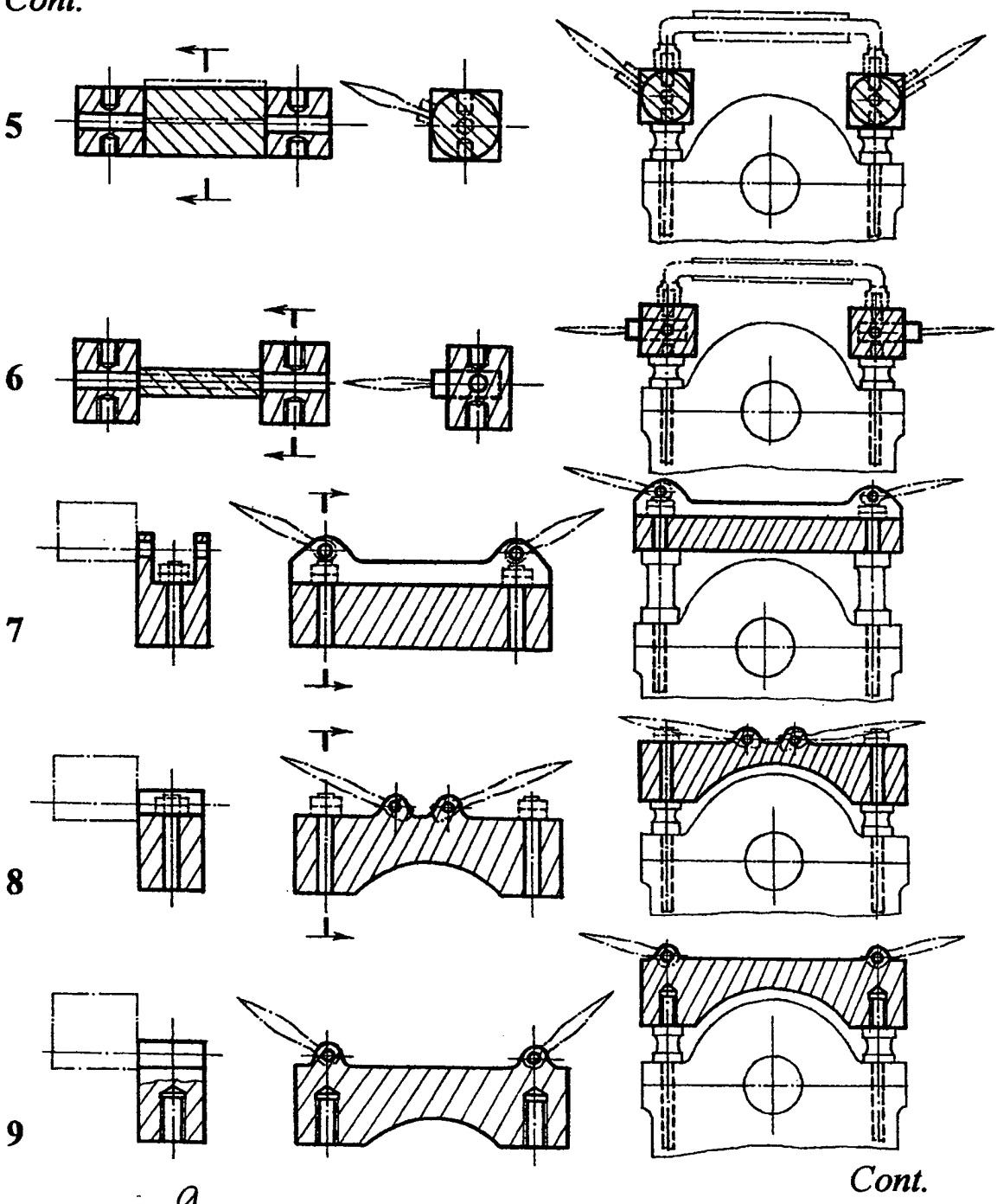
9

Fig. 4 Loads of the B-F-L-Ws (variants).

Various forms of the loads.

Turbine Generator Vibration Damper System. Vladilen Safonov.

Cont.



Cont.

9

Fig. A ***Continuation.*** **Loads of the B-F-L-Ws (variants).**
Vari us forms of the loads.

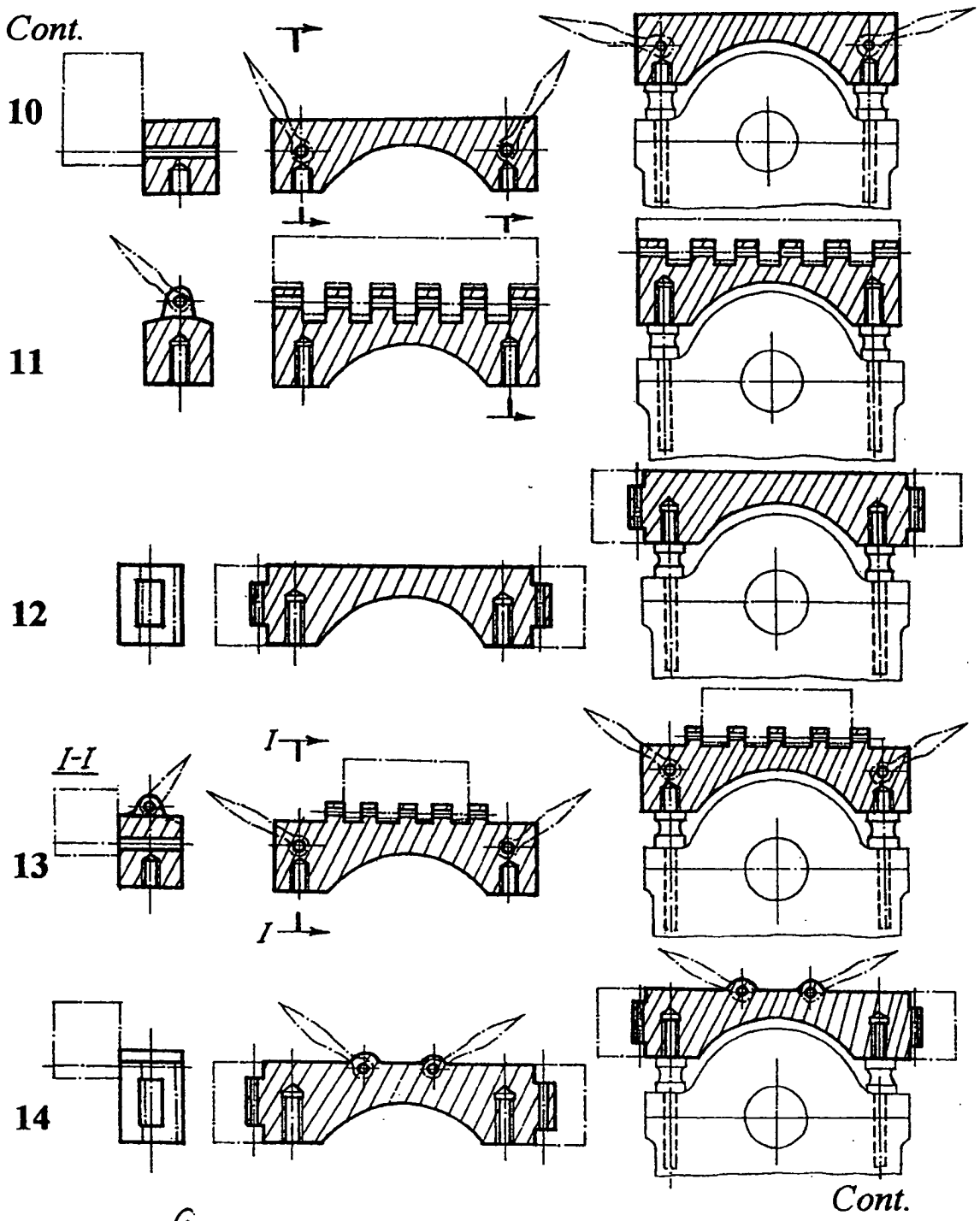
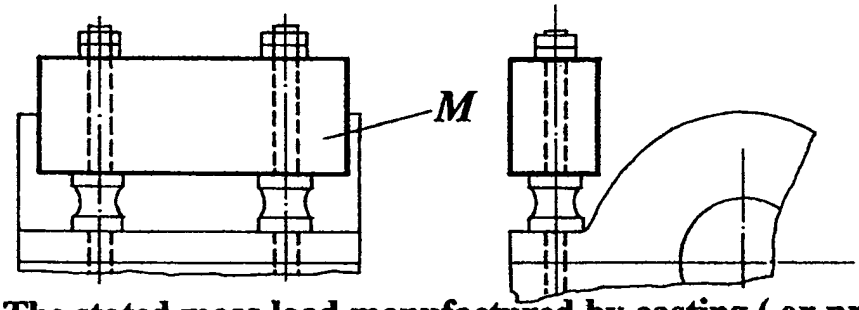


Fig. 4 ***Continuation.*** **Loads of the B-F-L-Ws (variants).**
Various f rms of the loads.

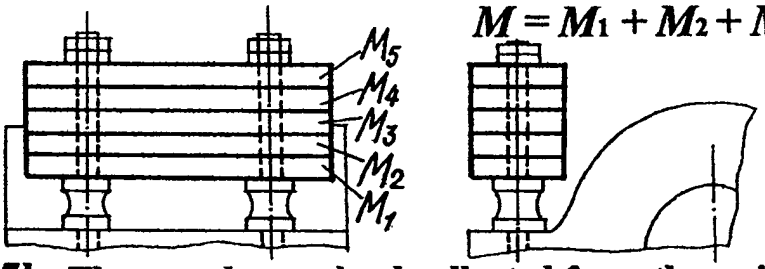
Turbine Generator Vibration Damper System. Vladilen Safonov.

Cont.

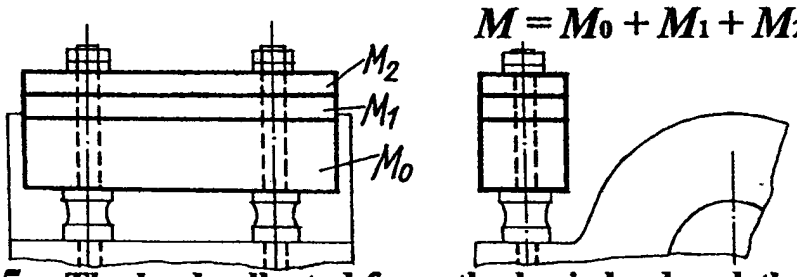
15. The ways of forming the loads (variants).



15a. The stated mass load manufactured by casting (or pressing, shaping, etc.).

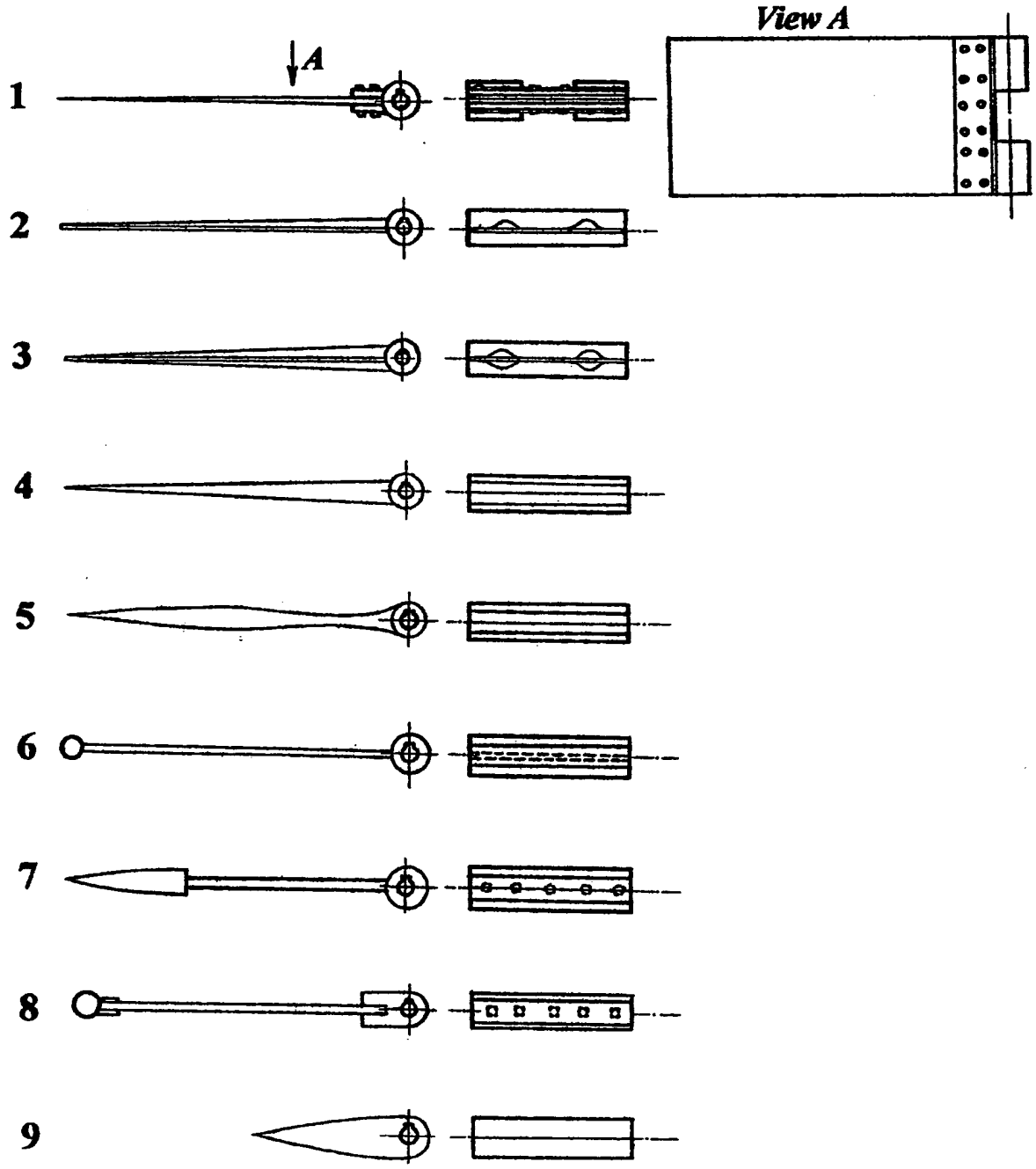


15b. The stated mass load collected from the weights.



15c. The load collected from the basic load and the additional weights.

Fig. 4 *Continuation.* Loads of the B-F-L-Ws (variants).
The ways f forming the loads.

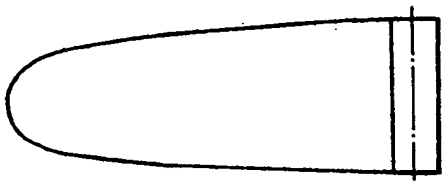


Cont.

Fig. 4a Wings of the B-F-L-Ws (variants).
Various f rms of the wings.

Cont.

10



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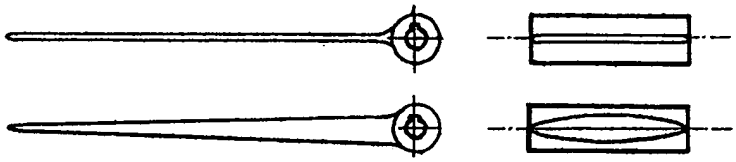

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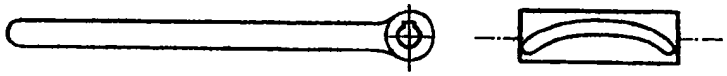
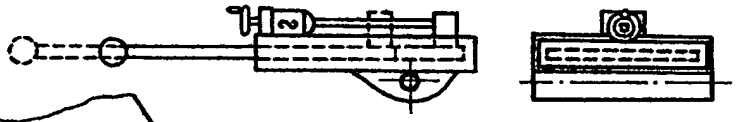


13

14



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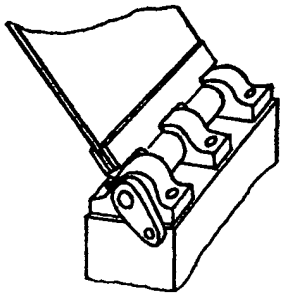

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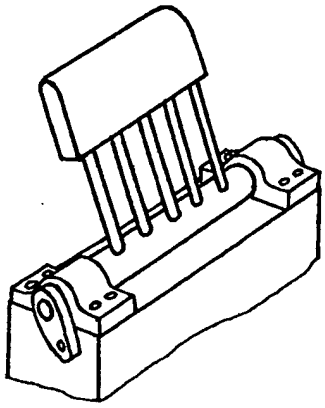


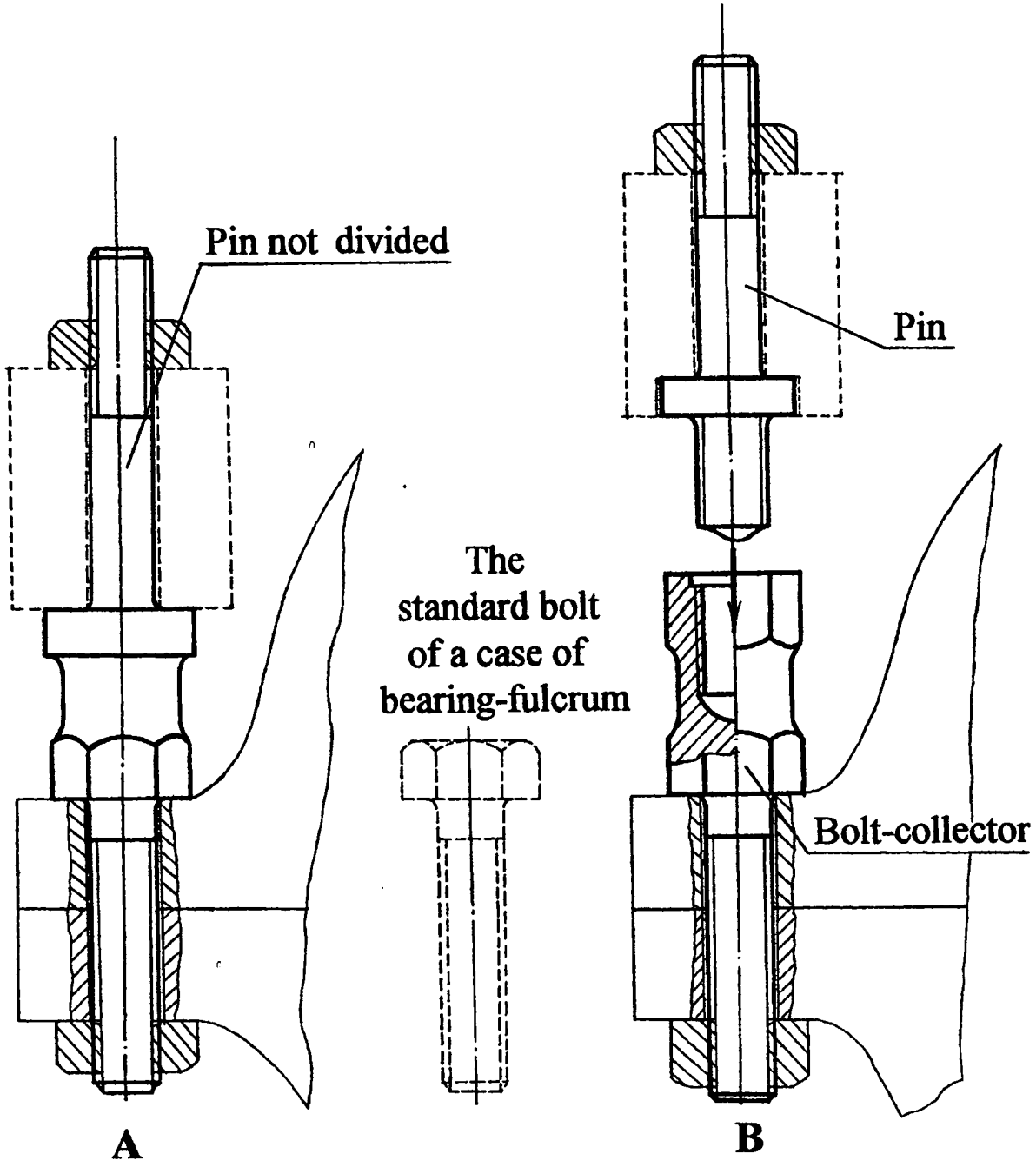
10

Fig. ~~4a~~ *Continuation.* Wings of the B-F-L-Ws (variants).

Various forms f the wings.

See also: *Preferable fixations of wings fulcra (on)to the loads and the joint–units* [Fig. ~~4~~h (par. 4)], *Folding wings of the B-F-L-Ws* (Fig. ~~11~~a).

17



Cont.

Fig. 4b Fixture units for fixing of loads of the B-F-L-Ws to a case of bearing-fulcrum (variants).

Cont.

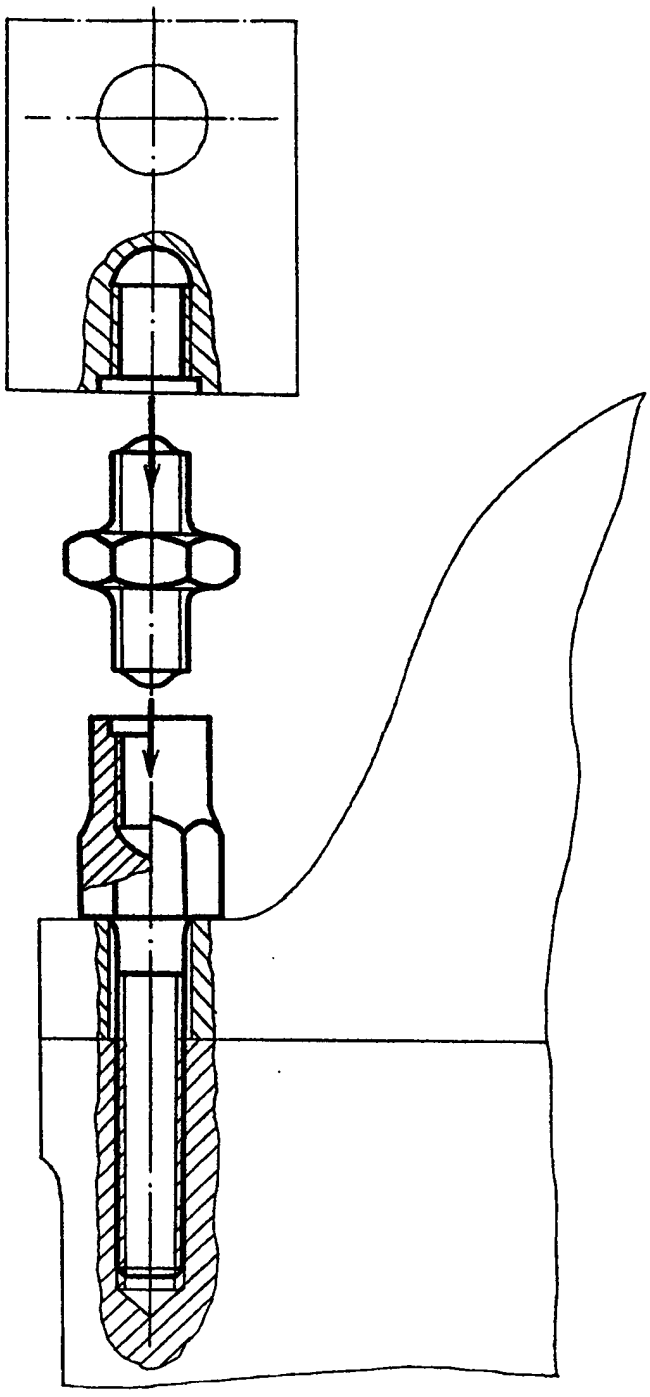
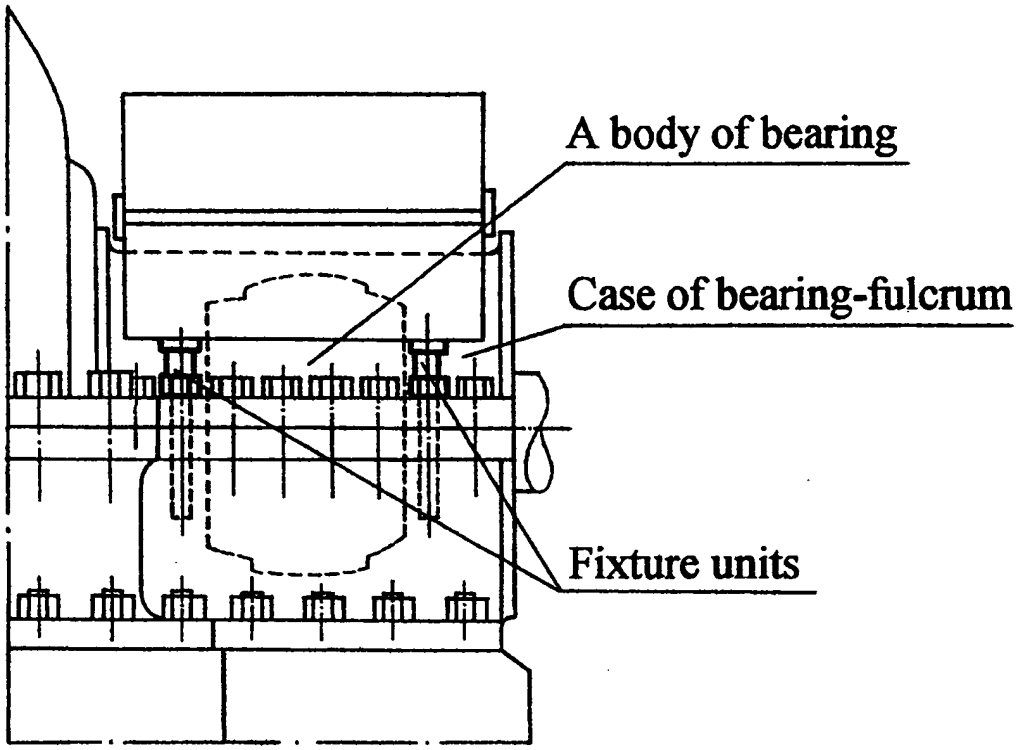


Fig. 4b *Continuation.* Fixture units for fixing loads of the B-F-L-Ws to a case of bearing-fulcrum (variant).



12

Fig. 4c Preferable setting of fixture units of the B-F-L-Ws.

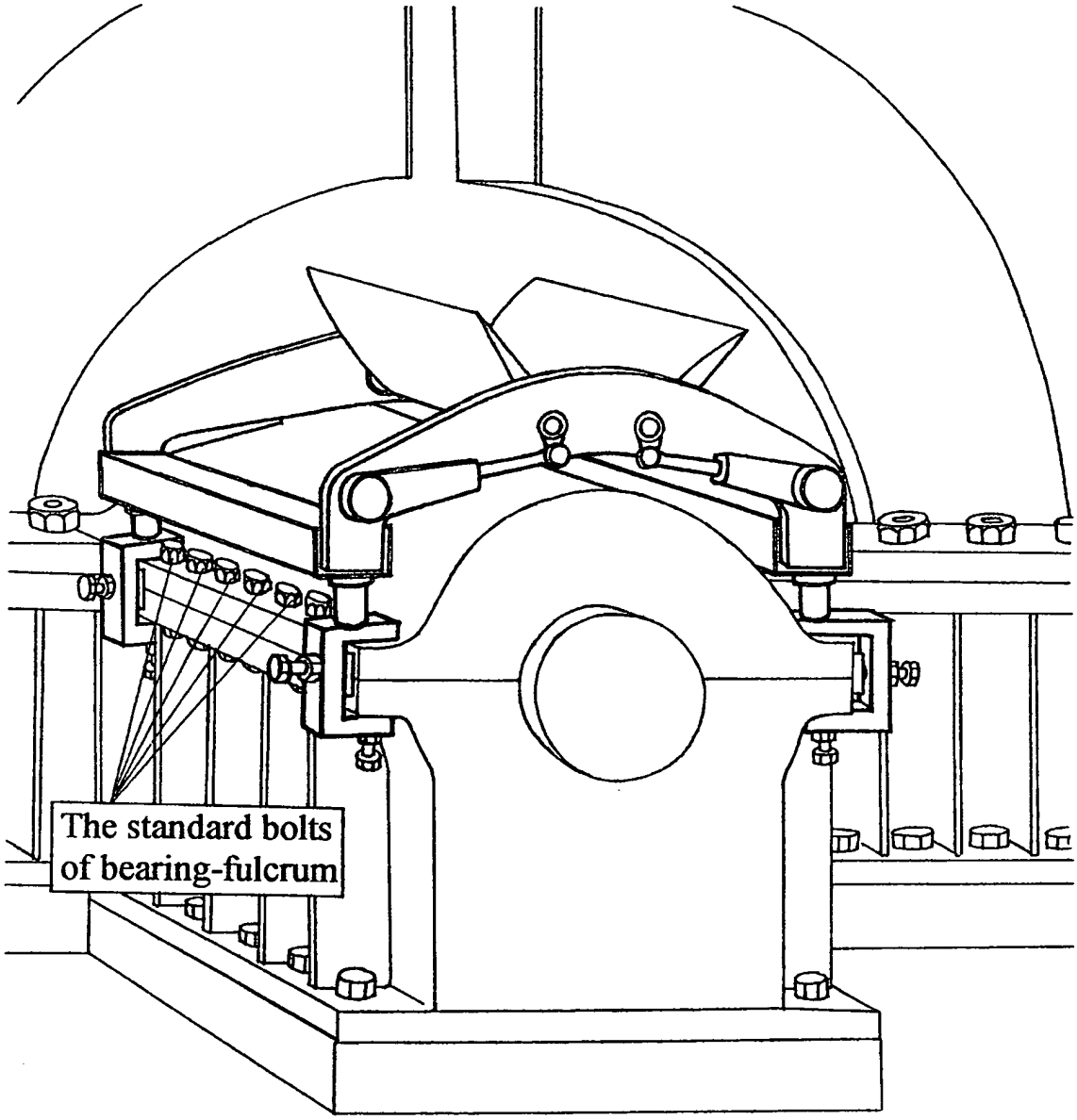


Fig. 13 Installation of the B-F-L-Ws with fixation which not requires replacement of the standard bolts of bearing--fulcrum (variant).

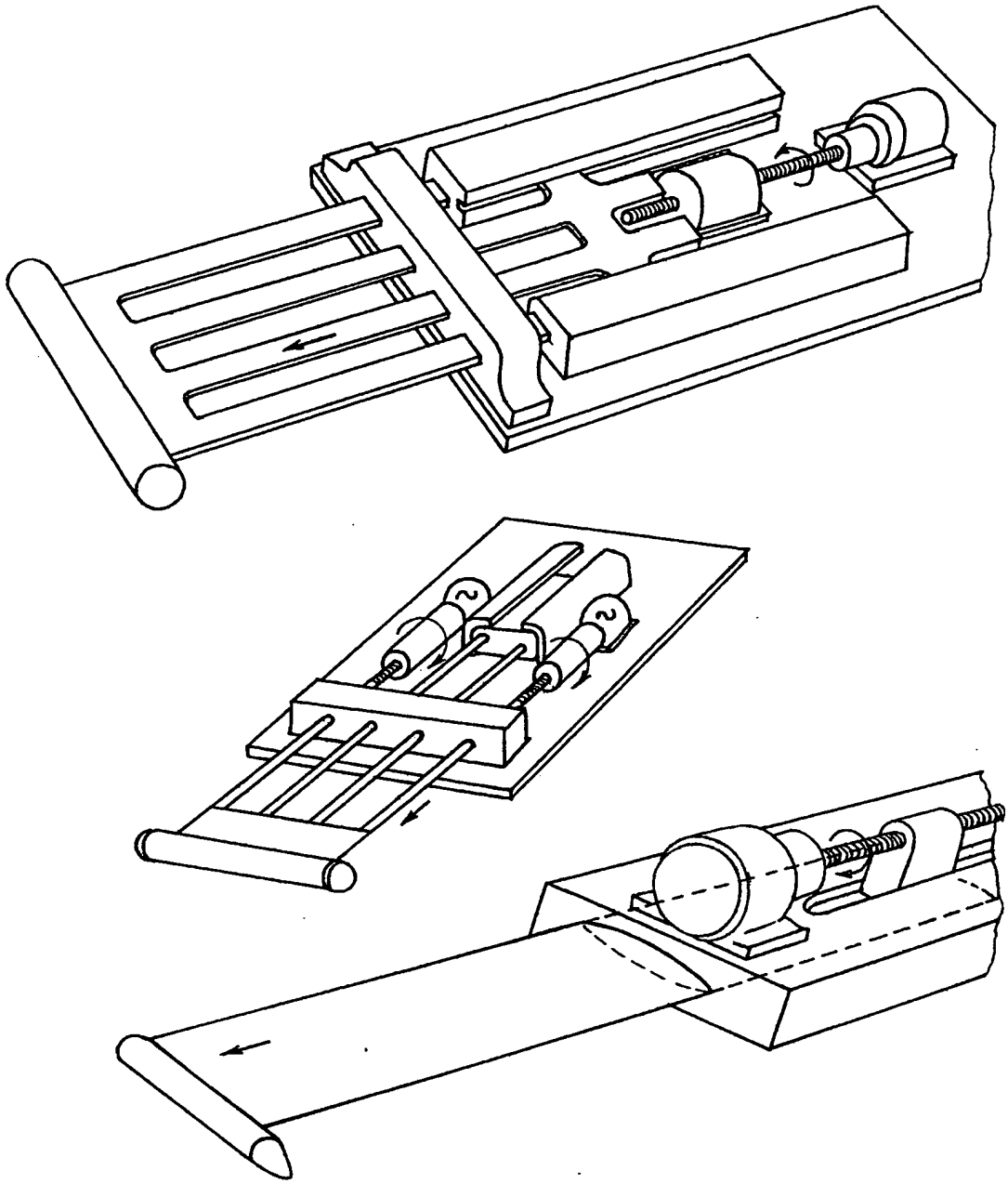
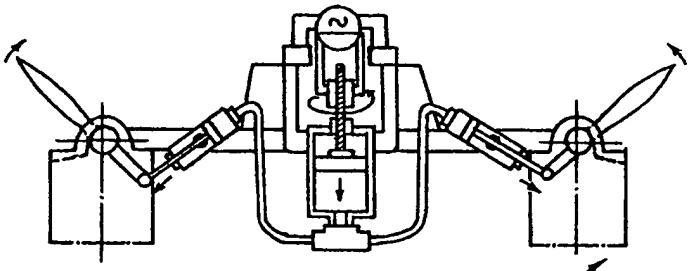
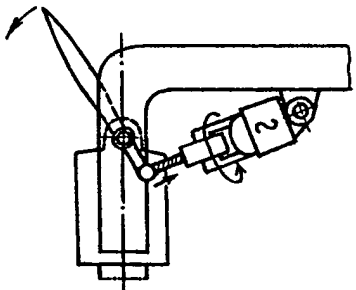


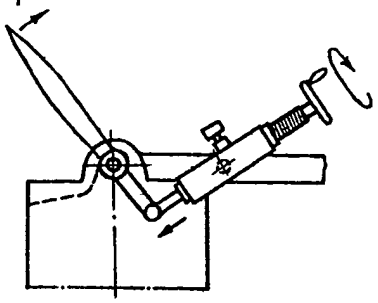
Fig. 4e Variants of units for changing the length of wings of the B-F-L-Ws.
See text in Specification.



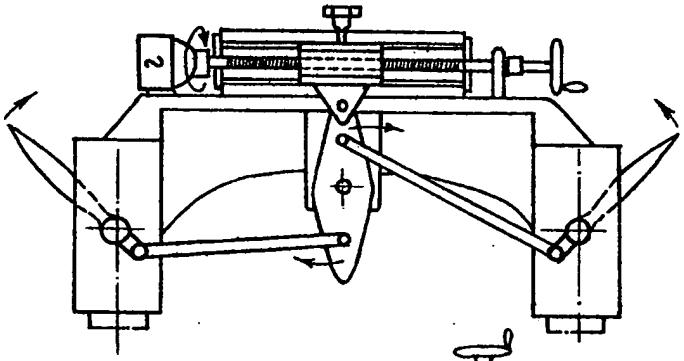
1. Hydraulically (electro-hydraulically) driven wings



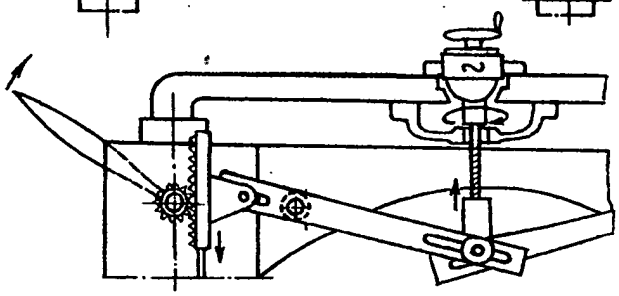
2. Electrically driven wing



3. Mechanically (manually) driven wing



4. Electro-mechanically (and manually) driven wings



5. Electro-mechanically (and manually) driven wings

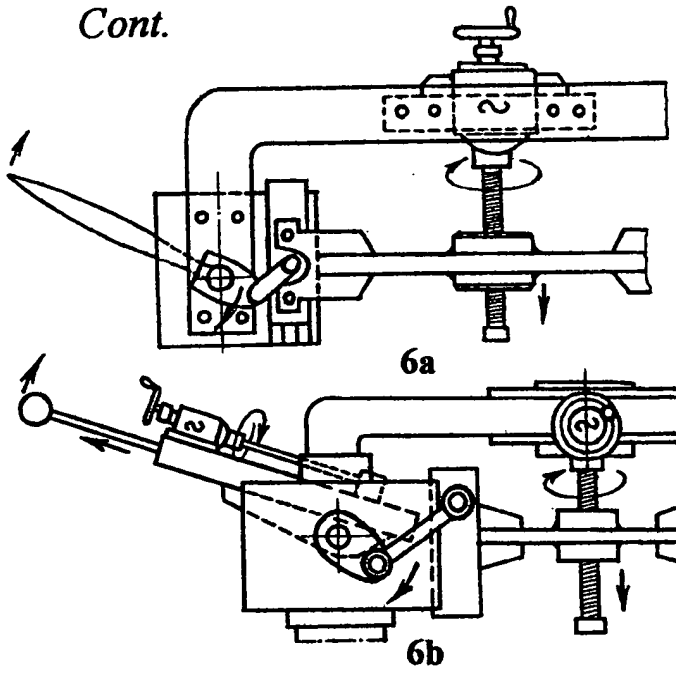
Cont.

15

Fig. 4 Various types of drivers (shown schematically) of units for turning wings of the B-F-L-Ws.
See text in Specification.

Turbine Generator Vibration Damper System. Vladilen Safonov.

Cont.



6. Electro-mechanically (and manually) driven wings

15

Fig. 4f ***Continuation.*** **Various types of drivers (shown schematically) of units f r turning wings of the B-F-L-Ws.**
See text in Specification.

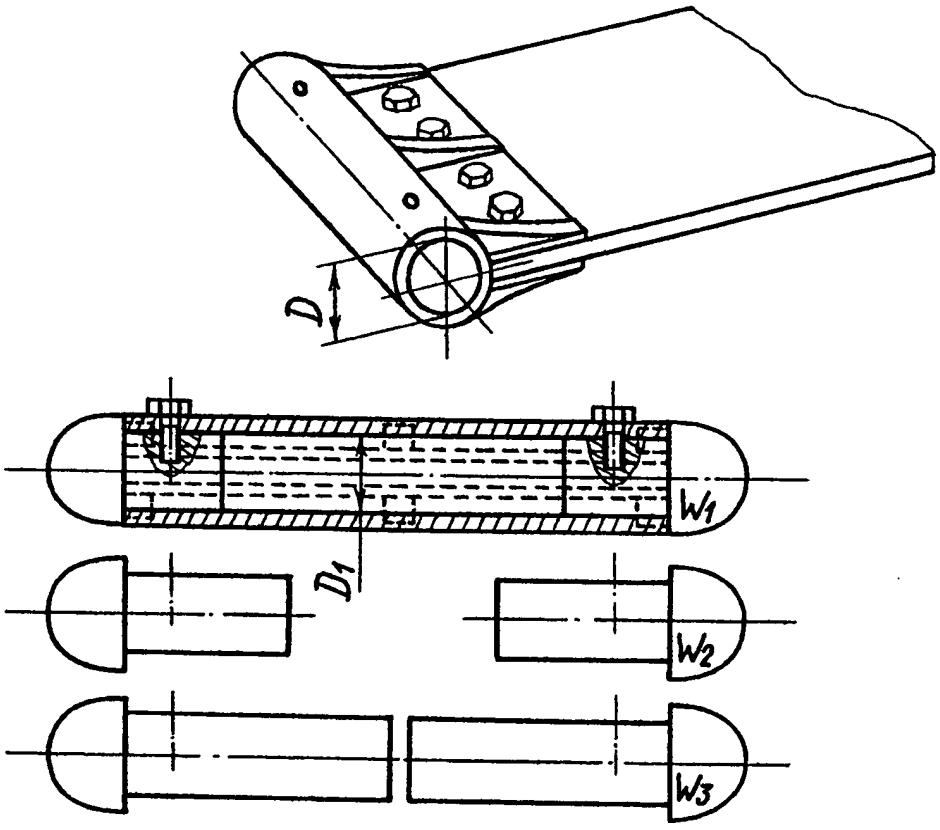
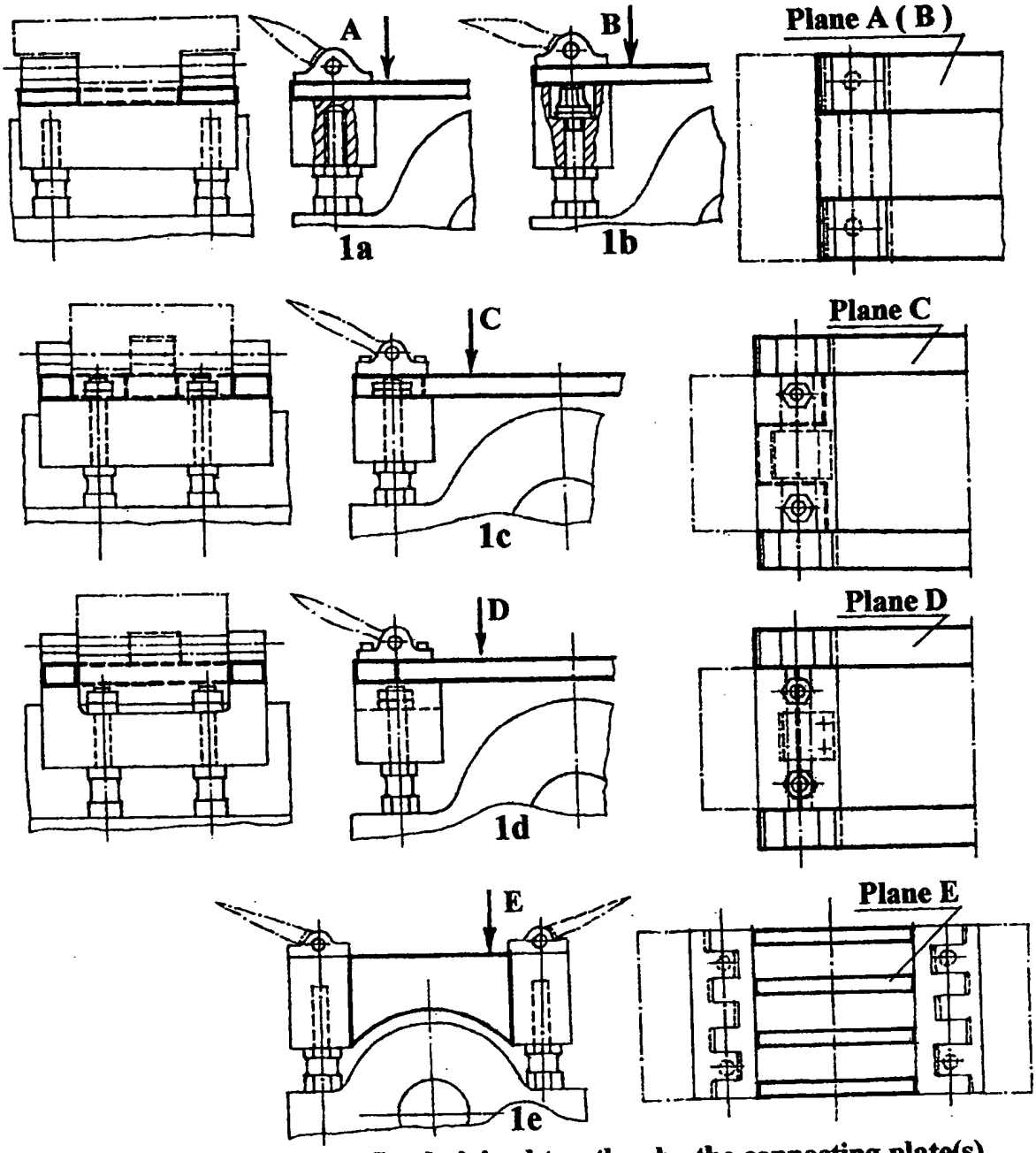


Fig. 4~~g~~ 16 A change of mass of wing of the B-F-L-Ws by attached weights (variant).

A change may be done by attached pairs of weights of various length and diameter D_1, D_2, ..., etc.



1. The two loads are firmly joined together by the connecting plate(s) [or bars, ribs, etc.].

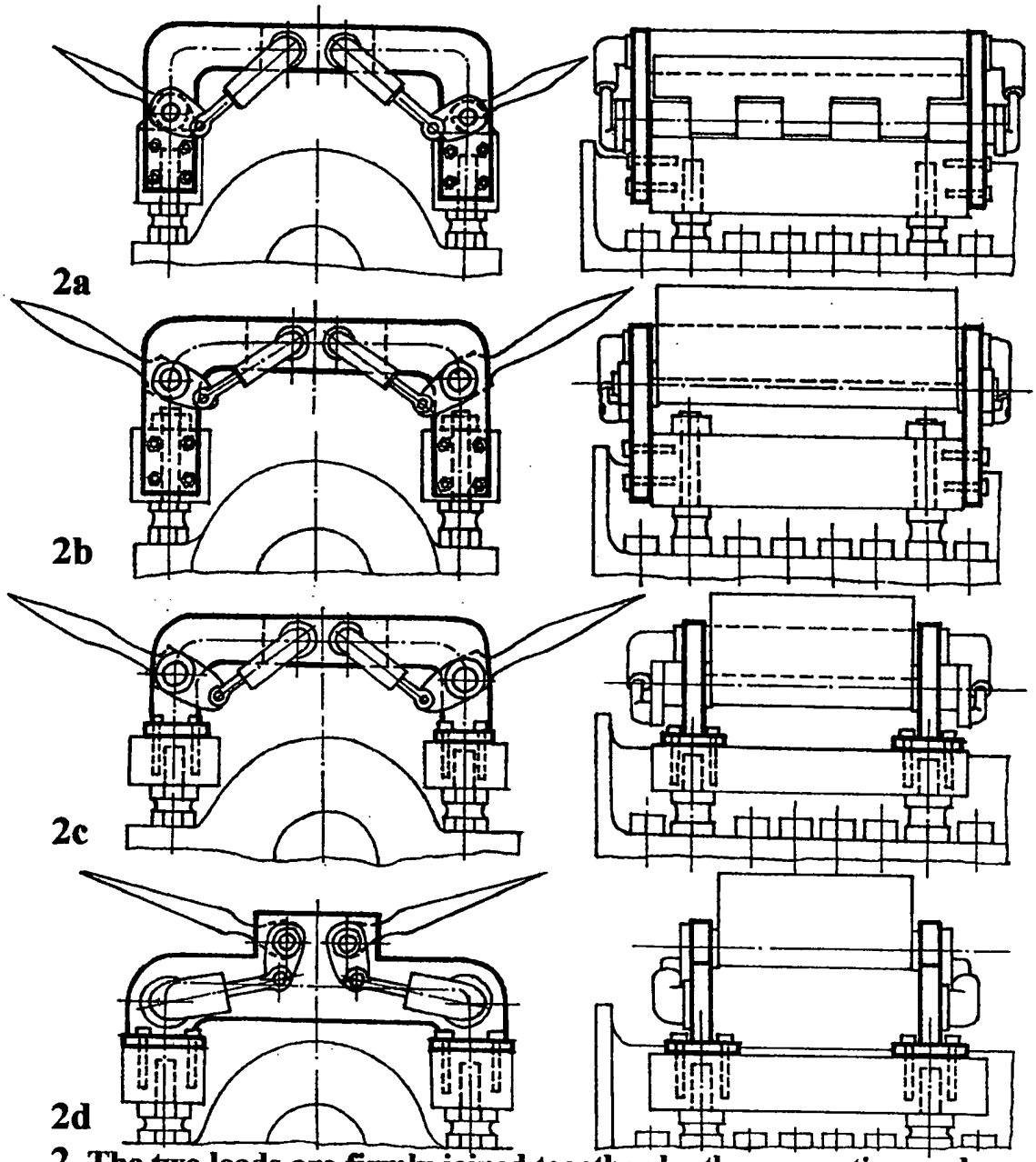
Cont.

17

Fig. 4a Joint-units of the B-F-L-Ws (variants).

Turbine Generator Vibration Damper System. Vladilen Safonov.

Cont.



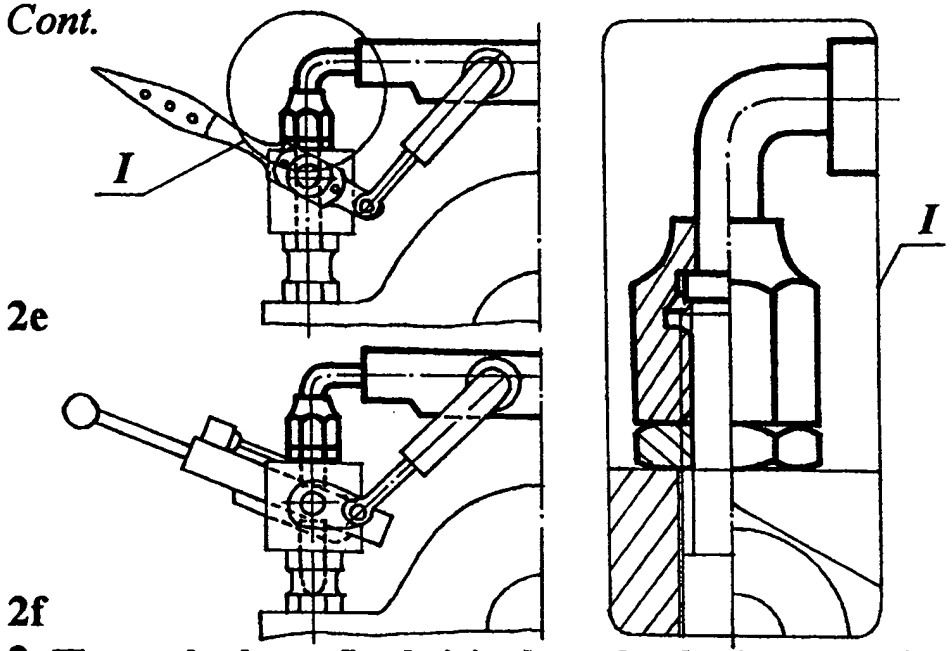
2. The two loads are firmly joined together by the connecting arch--shaped units. (For variants 2b, 2c, 2d wings fulcra are fixed onto the joint-unit).

Cont.

17

Fig. 4h ***Continuation.*** **Joint-units of the B-F-L-Ws (variants).**

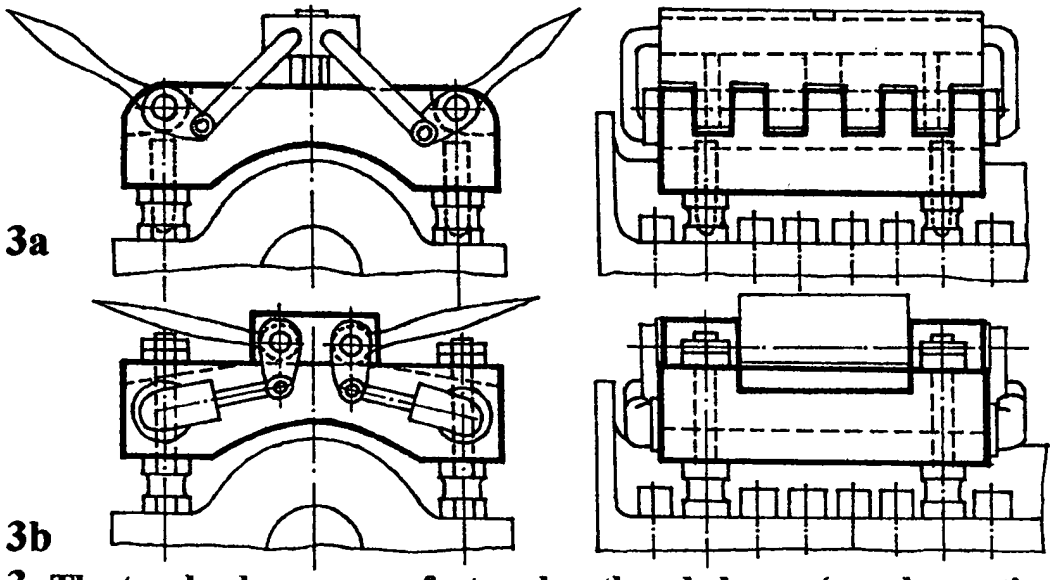
Cont.



2e

2f

2. The two loads are firmly joined together by the connecting arch--shaped (pipe) units.



3a

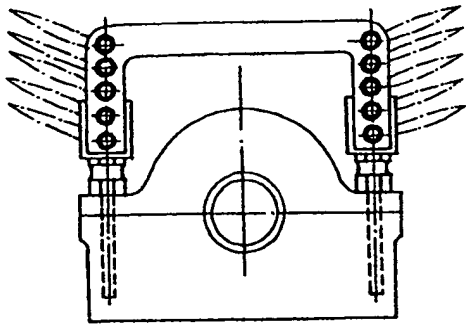
3b

3. The two loads are manufactured as the whole one (e.g. by casting, pressing, shaping, etc.) with the arch jointing. [For variant 3b wings fulcra are fixed onto the joint-unit].

Cont.

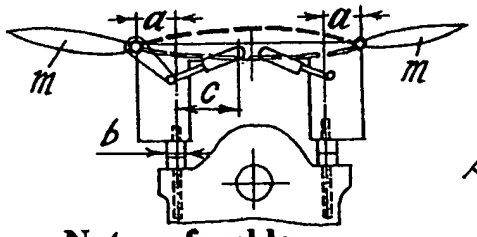
Fig. 4b *Continuation.* Joint-units of the B-F-L-Ws (variants).

Cont.

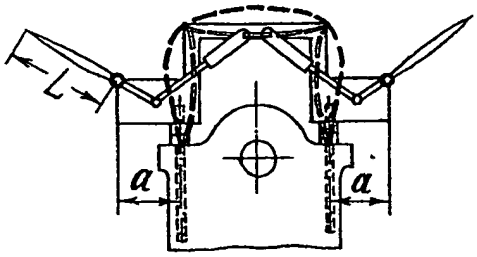


4a. The most preferable variants of fixation of wings fulcra (on)to the loads and the joint-units.

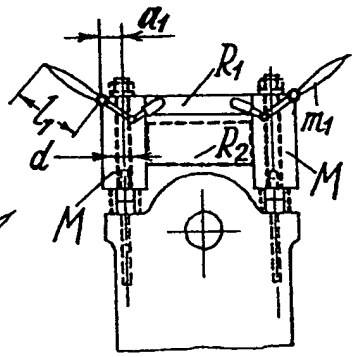
4b. Fixation with the eccentricity *a* (external).



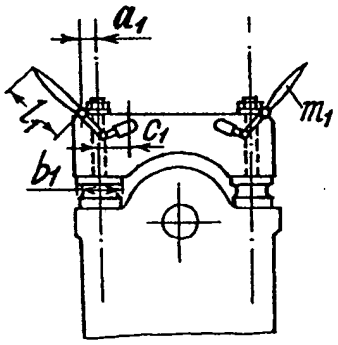
Not preferable



Not preferable



Corrected



Preferable

The recommendations to prefer the fixing of the wings fulcra:

1) $a \rightarrow a_1 = a_{min.}$

2) $b_1 > b$.

3) $a_1 < 1/2\ b_1$.

4) $l_1 < L$, ($m_1 < m$); $c_1 < c$.

5) The system [formed out of the loads M, the fixture units d, the joint-units R_1, R_2] is so rigid that it may also successfully resist the additional momentum originated from the eccentricity a_1.

4. Some recommendations for preferable fixing of wings fulcra (on)to the loads and the joint-units.

Cont.

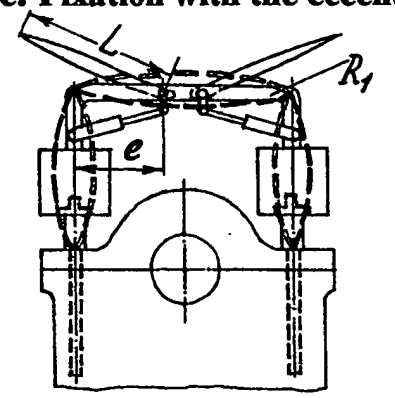
17

Fig. 4b *Continuation.* Joint-units of the B-F-L-Ws (variants).

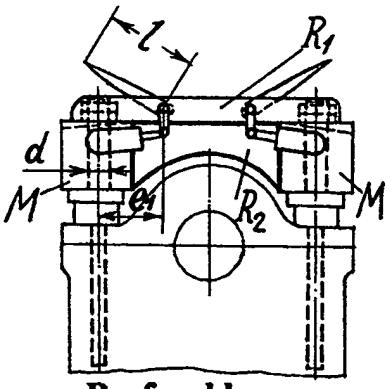
Turbine Generator Vibration Damper System. Vladilen Safonov.

Cont.

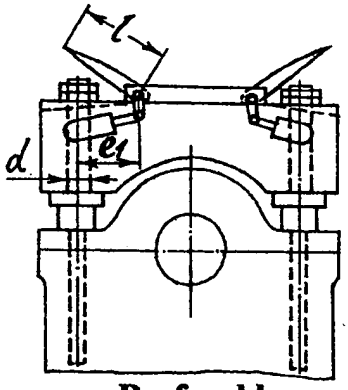
4c. Fixation with the eccentricity e (internal).



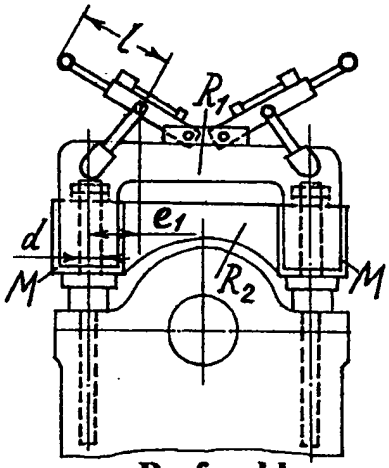
Not preferable



Preferable



Preferable



Preferable

The recommendations to prefer the fixing of the wings fulcra:

1) e, $e_1 \rightarrow e_{min}$.

2) $l < L$ (e.g. work within limited space for spreading the wings).

3) The system [formed out of the loads M, the fixture units d, the joint-units R_1, R_2] is so rigid that it may also successfully resist the additional momentum originated from eccentricity e_1.

4. Some recommendations for preferable fixing of wings fulcra (on)to the loads and the joint-units.

Fig. 4h *Continuation.* Joint-units of the B-F-L-Ws (variants).

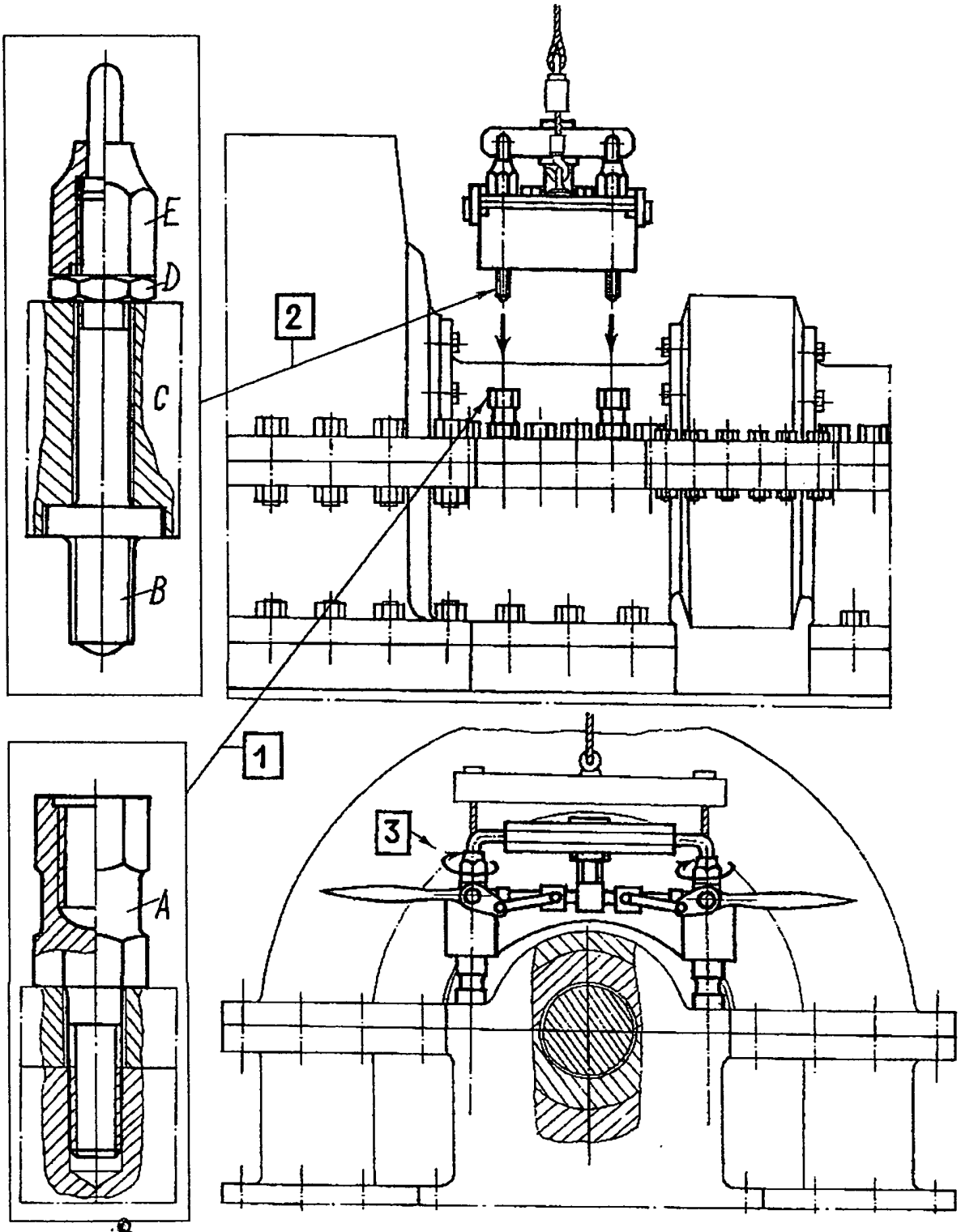


Fig. 4i Operations (in number and sequence) to install the B-F-L-Ws [variant]. See text in Specification.

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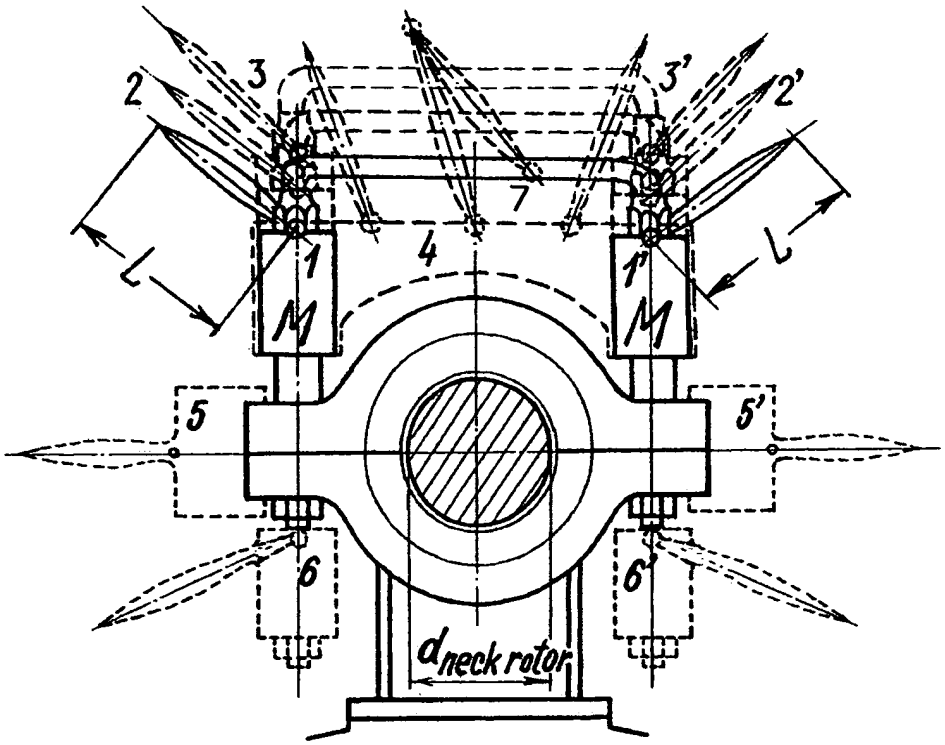


Fig.19 Placement of the B-F-L-Ws around bearing-fulcrum at T-G-S in direction parallelly to rotor axis.

Placement:

(1 & 1') - the most adequate and practically possible variant.

(2 & 2'), (3 & 3') - additional (and limited) variants.

(1 & 1') + (6 & 6') – adequate, but practically not always possible variant.

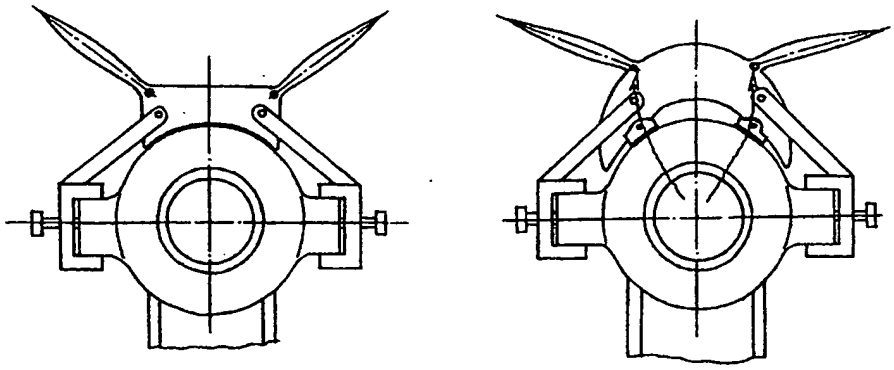
(4) – most adequate variant.

(5 & 5') - adequate, but practically not always possible variant.

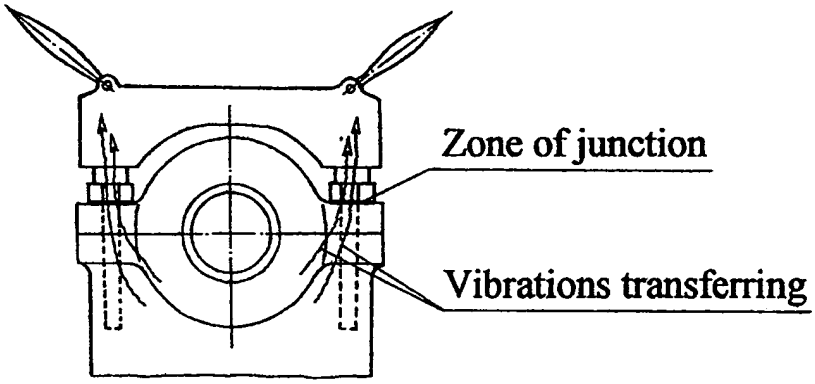
(6 & 6') - adequate, but practically not always possible; not preferable variant as not increasing the weight of an upper cover of bearing-fulcrum. Loads may be used with wings, or without wings (as additional variant).

(7) - adequate, but practically n t always possible variant.

Here the wing is shown folding (and changeable in length, width and weight).



1) Incorrect placements.



2) Correct placement.

Fig. 20 Correct and incorrect placements of the B-F-L-Ws at bearing-fulcrum /if to follow the instructions of the B-F-L-Ws method/.

See text in Specification.

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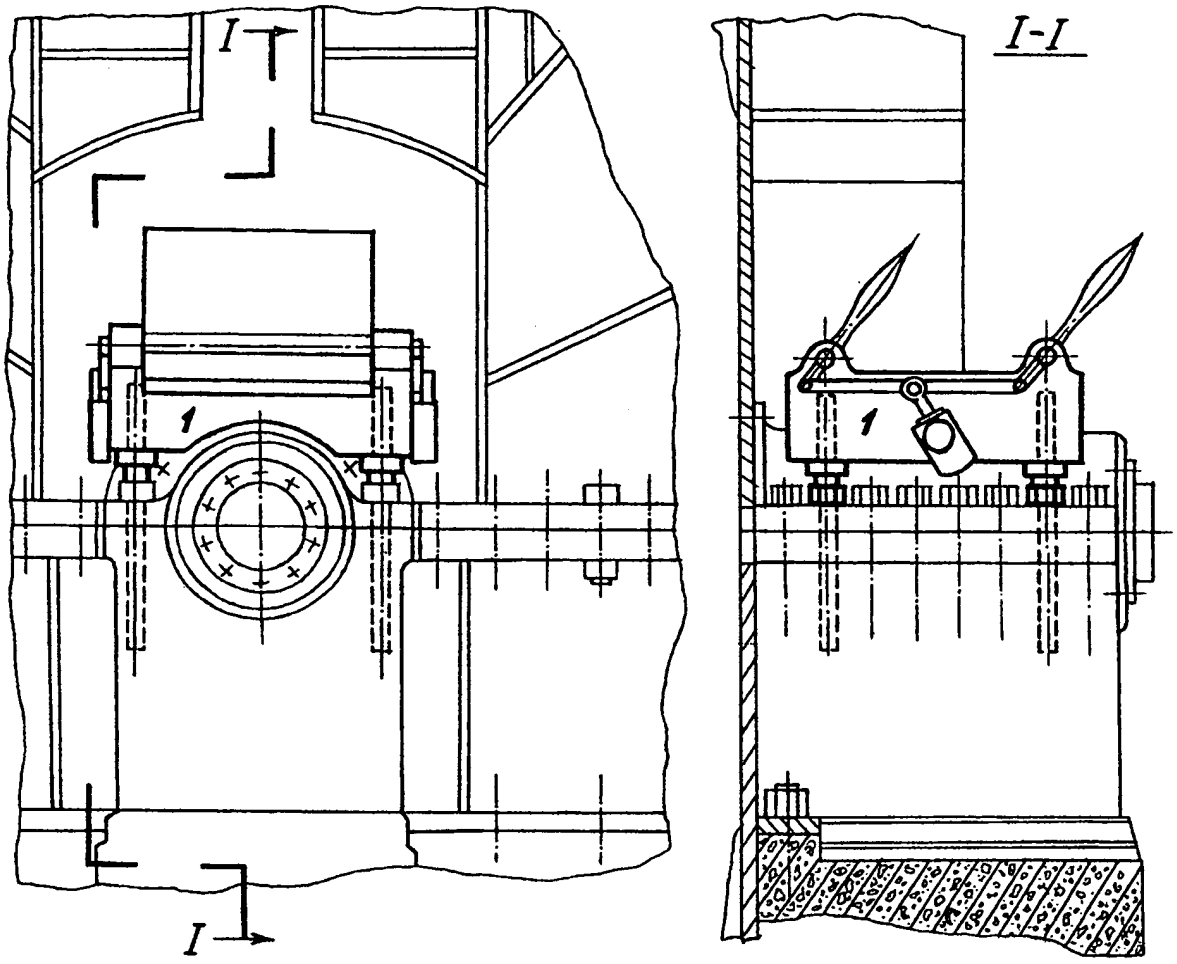


An axial stress bearing-fulcrum

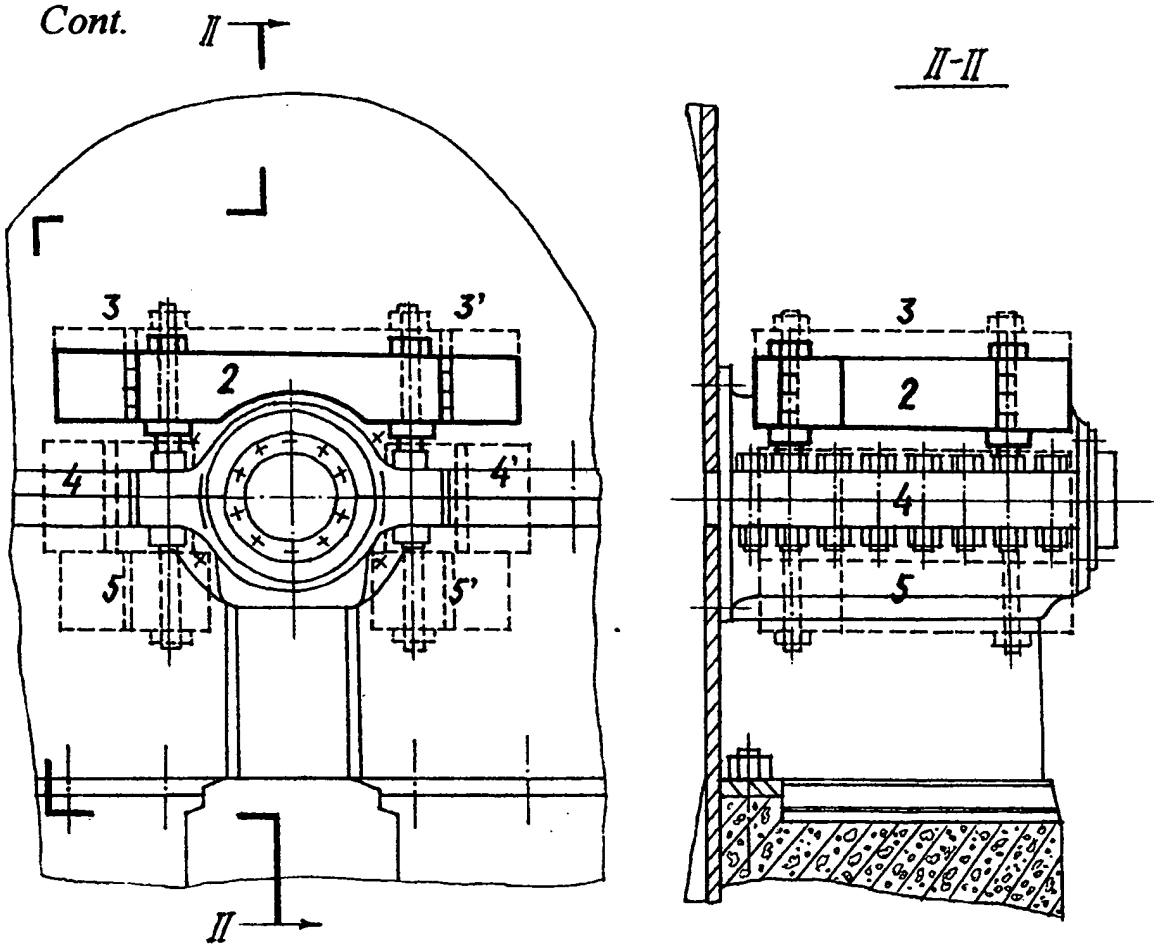
Cont.

21

Fig. 2b Placement of the B-F-L-Ws upon bearing--fulcrum at T-G-S in direction perpendicularly to rotor axis.

Placement:

1 - the most adequat and practically possible variant.



21

Fig. 5b *Continuation.* **Placements of the B-F-L-Ws around bearing-fulcrum at T-G-S in direction perpendicularly to rotor axis.**

Placements:

2 - most adequate variant.

(3 & 3') - additional variants [for loading].

(4 & 4') - adequate, but practically not always possible variant.

(5 & 5') - adequate, but practically not always possible variant.

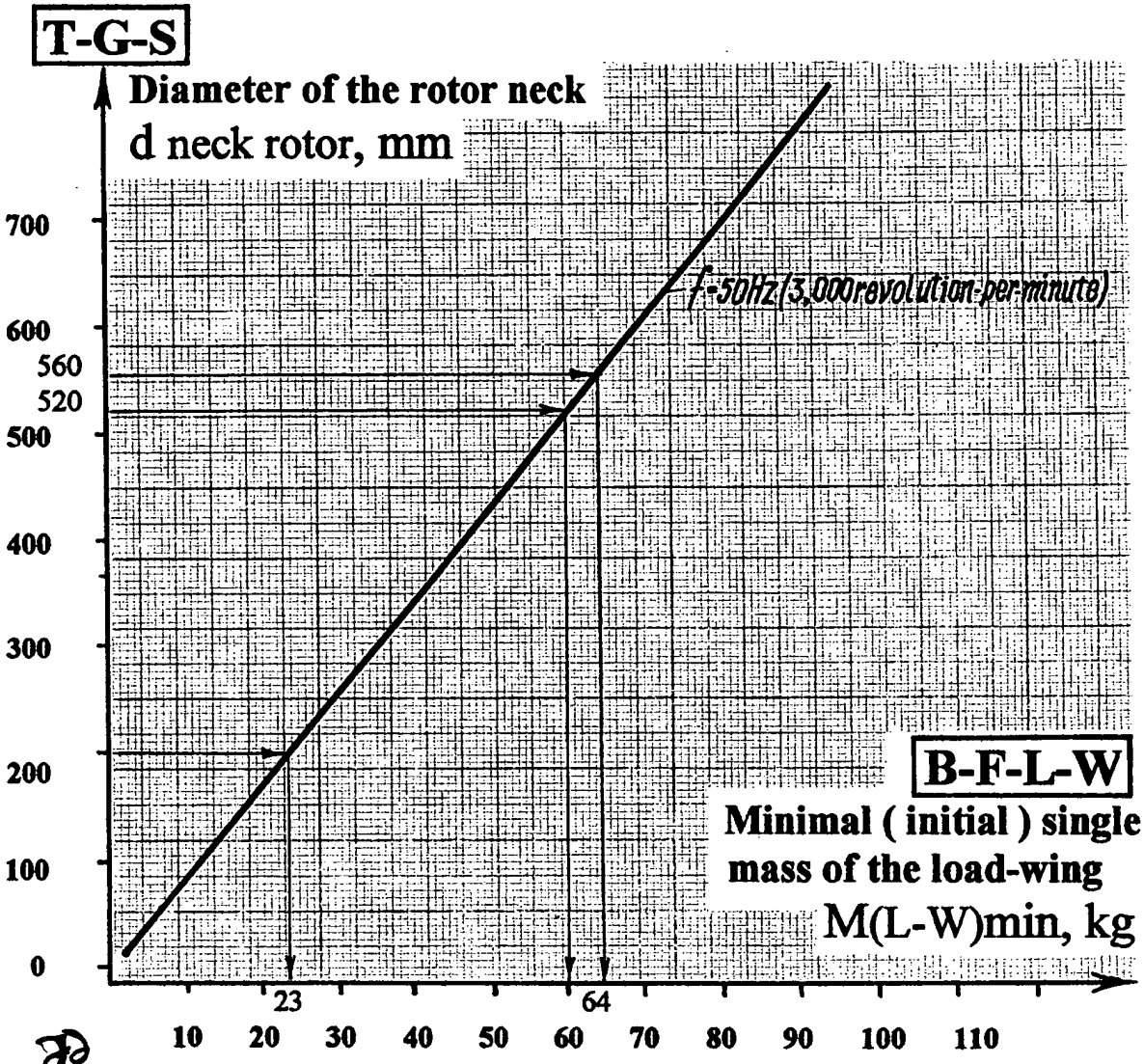


Fig. 6 The graph for determination of initial single mass of the load-wing $M_{(L-W)min}$ of B-F-L-W as function of diameter of the rotor neck $d_{neck\ rotor}$ of T-G-S [by Vladilen Safonov].
(See text in Specification).
The graph may be used for determination of minimal /initial/ single mass of the load-wing: for example, for T-G-S with designed operating frequency f = 50 Hz (3000 revolutions-per-minute), for $d_{neck\ rotor}$ = 560 mm - - $M_{(L-W)min}$ = 64 kg; f r $d_{neck\ rotor}$ = 520 mm - - $M_{(L-W)min}$ = 60 kg; for $d_{neck\ rotor}$ = 200 mm - - $M_{(L-W)min}$ = 23kg.

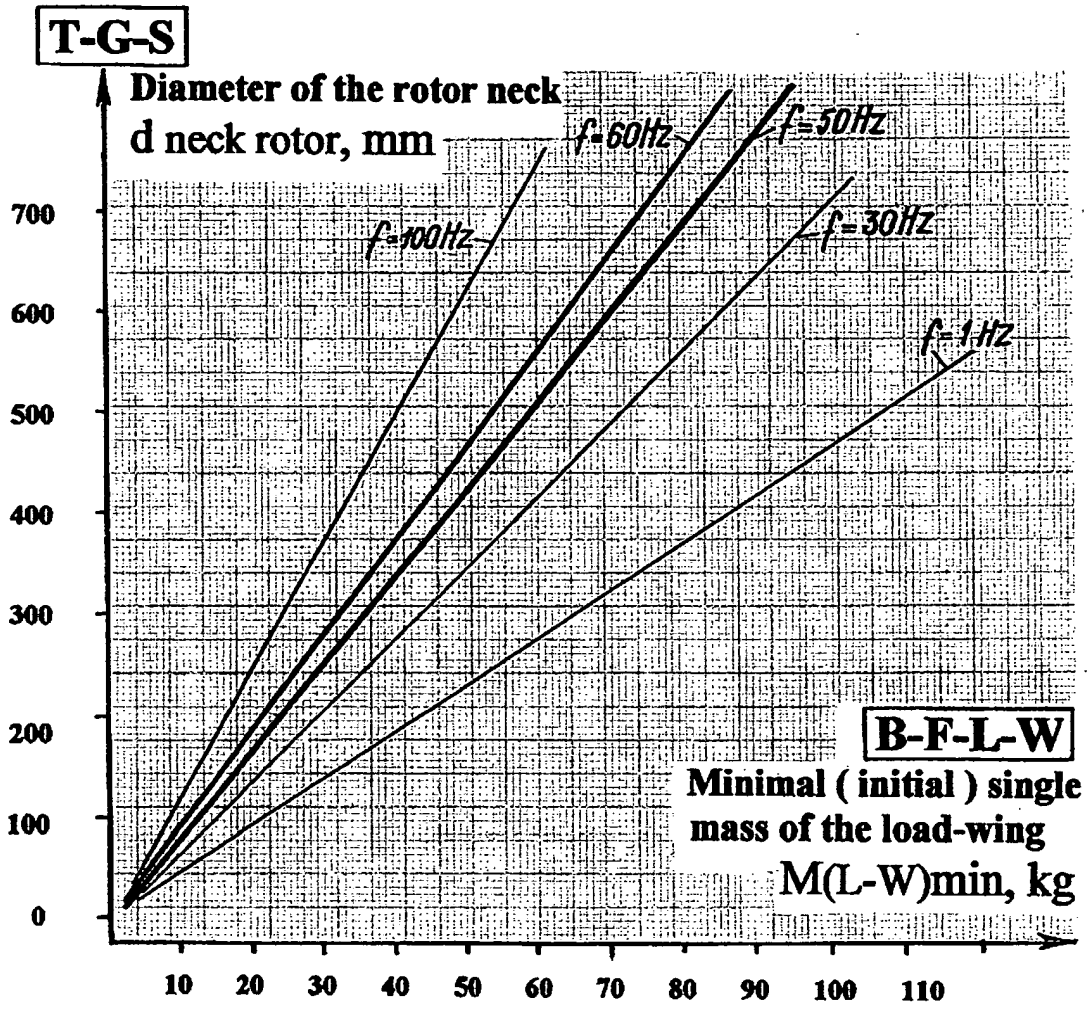


Fig. 23 The graphs for determination of initial single mass of the load-wing $M_{(L-W)min}$ as function of diameter of the rotor neck $d_{neck\ rotor}$, for various values of designed operating frequency f of T-G-Ss [by Vladilen Safonov].
(See text in Specification).

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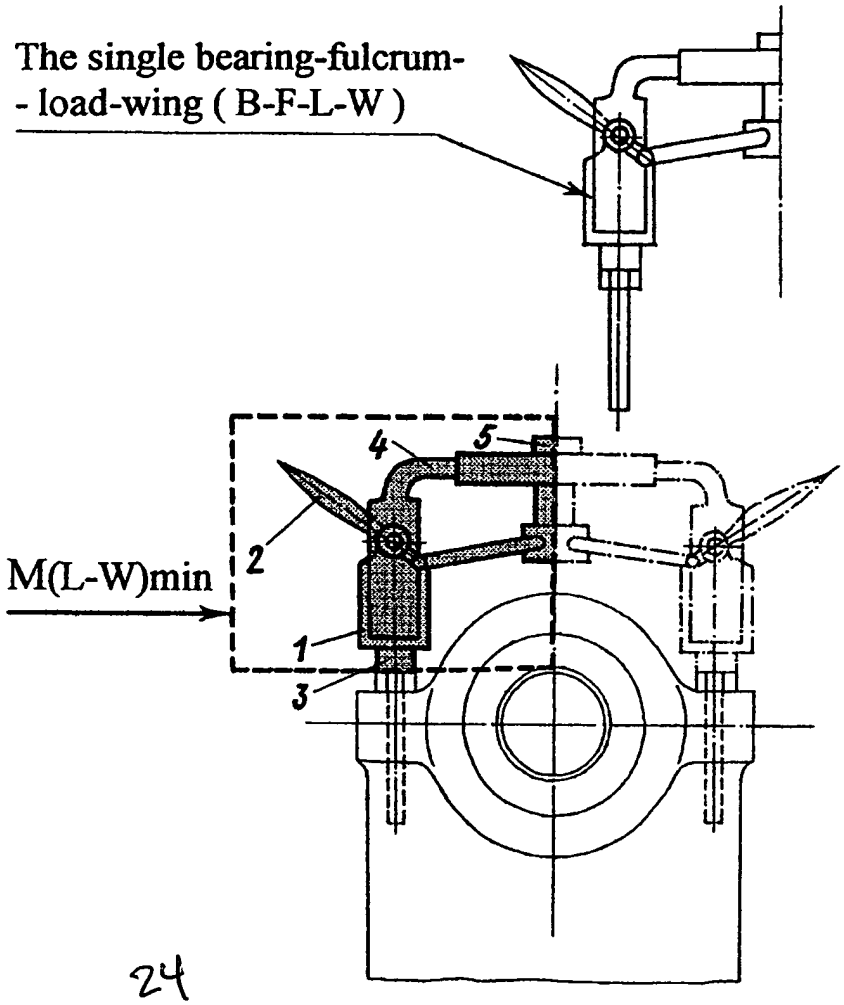
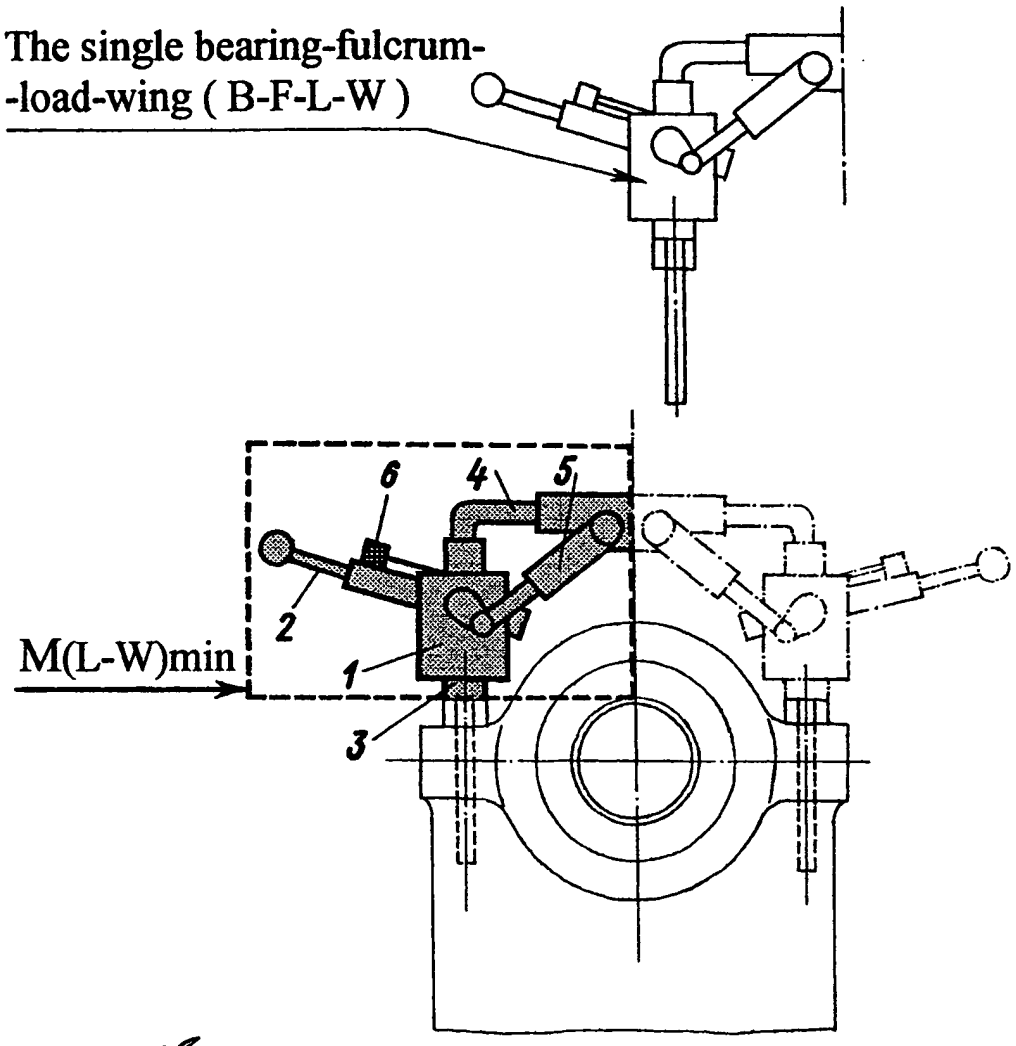


24

Fig. 7 Distribution of the minimal /initial/ single mass of the load-wing M(L-W)min among all elements and mechanisms, forming the single bearing-fulcrum-load-wing (B-F-L-W).

Removal of vibrations in wide diapasons.
Placement of the B-F-L-Ws in direction parallelly to rotor axis.
A total mass of the bearing-fulcrum-loads-wings (the B-F-L-Ws) is equal to a double mass of the single bearing-fulcrum-load-wing (B-F-L-W).
See text in Specification.



25

Fig. 8 Distribution of the minimal /initial/ single mass of the load-wing M(L-W)min among all elements and mechanisms, forming the single bearing-fulcrum-load-wing (B-F-L-W).

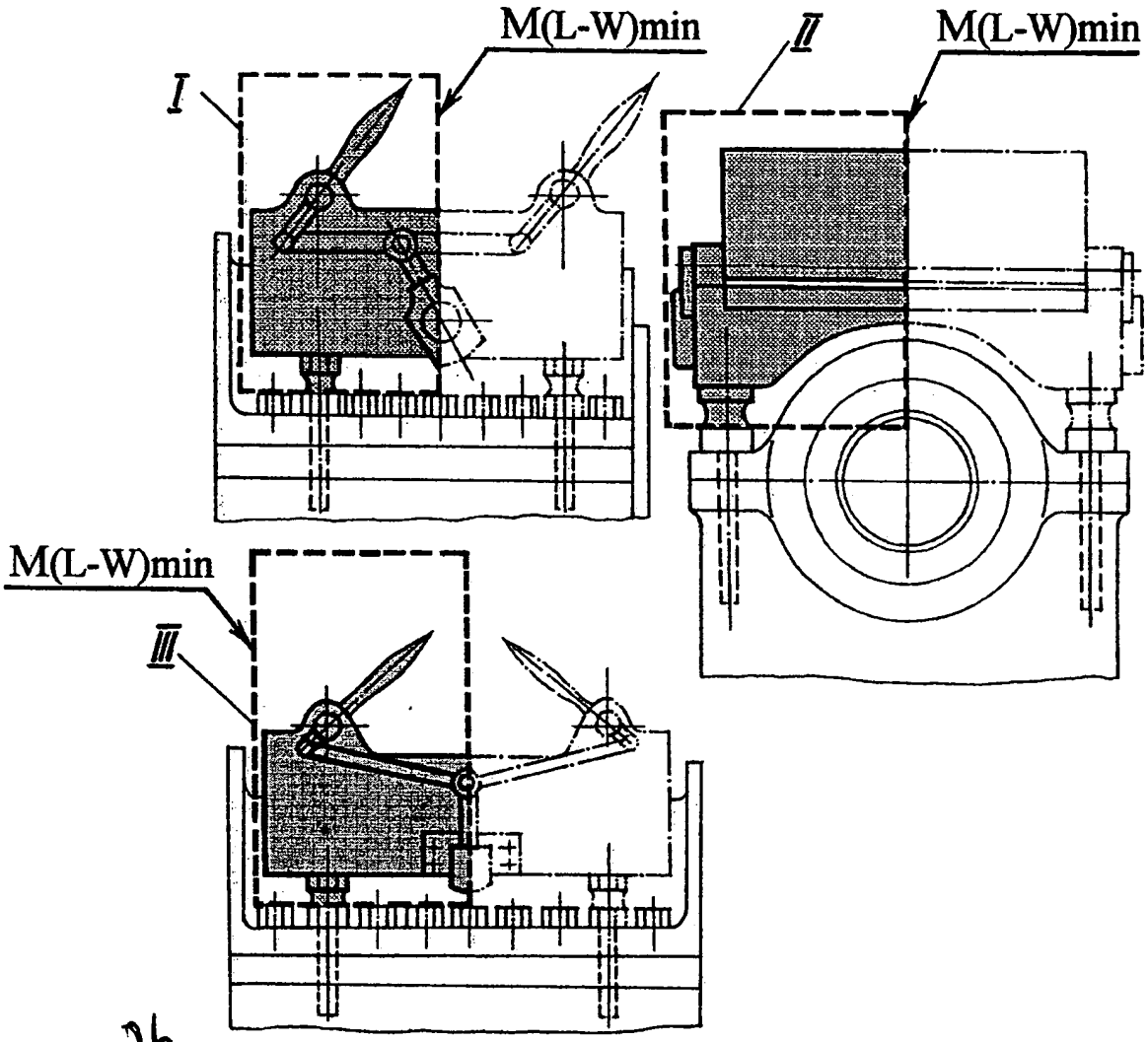
Removal of vibrations in super-wide diapasons.

Placement of the B-F-L-Ws in direction parallelly to rotor axis.

A total mass of the bearing-fulcrum-loads-wings (the B-F-L-Ws) is equal to a d uble mass of the single bearing-fulcrum-load-wing (B-F-L-W).

See text in Specification.

Turbine Generator Vibration Damper System. Vladilen Safonov.



26

Fig. 9 Distribution of the minimal /initial/ single mass of the load-wing M(L-W)min among all elements and mechanisms, forming the single bearing-fulcrum-load-wing (B-F-L-W).

Placement of the B-F-L-Ws in direction perpendicularly to rotor axis. See text in Specification.

Turbine Generator Vibration Damper System. Vladilen Safonov.

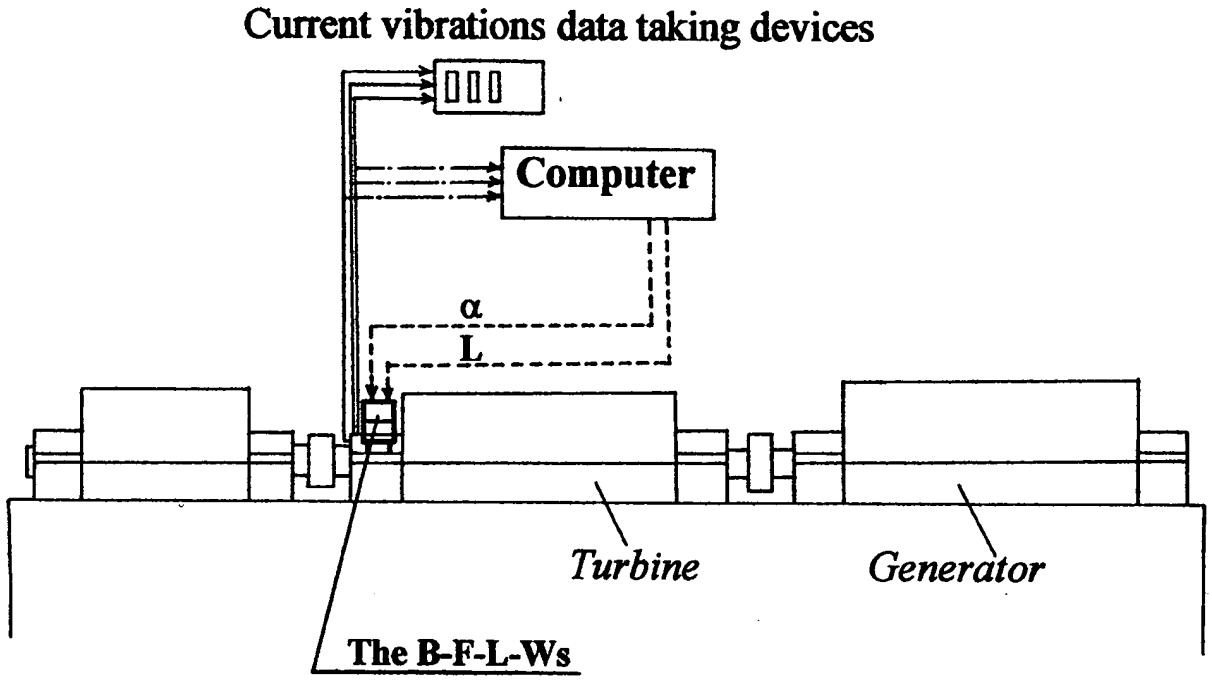
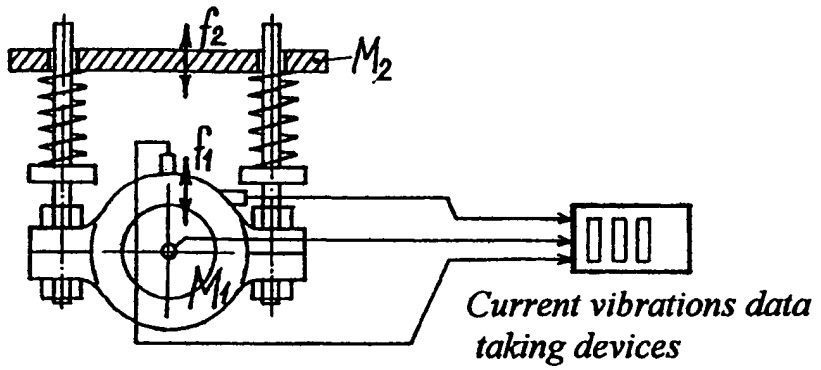


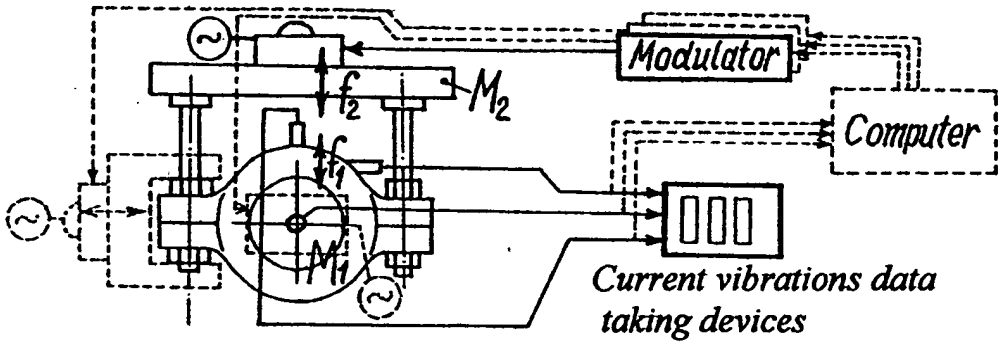
Fig. 10 Connecting of computer with the database to the bearing vibrations indicatory system to conduct removal of beyond-normal vibrations at the bearing-fulcrum automatically.

Turbine Generator Vibration Damper System. Vladilen Safonov.



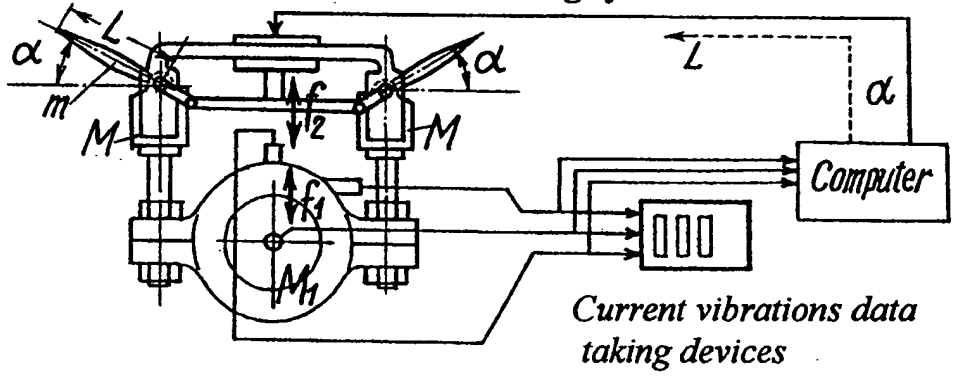
a)

The 'mass and spring' vibrating system method.



b)

The 'mass and vibrator' vibrating system method.



c)

The B-F-L-Ws method.

Fig. 1 Other methods of damping vibration [a), b)] -- but of extremely limited capabilities to be used upon bearings-fulcra zones at T-G-Ss -- in comparison with the B-F-L-Ws method [c)].

See text.

Turbine Generator Vibration Damper System. Vladilen Safonov.

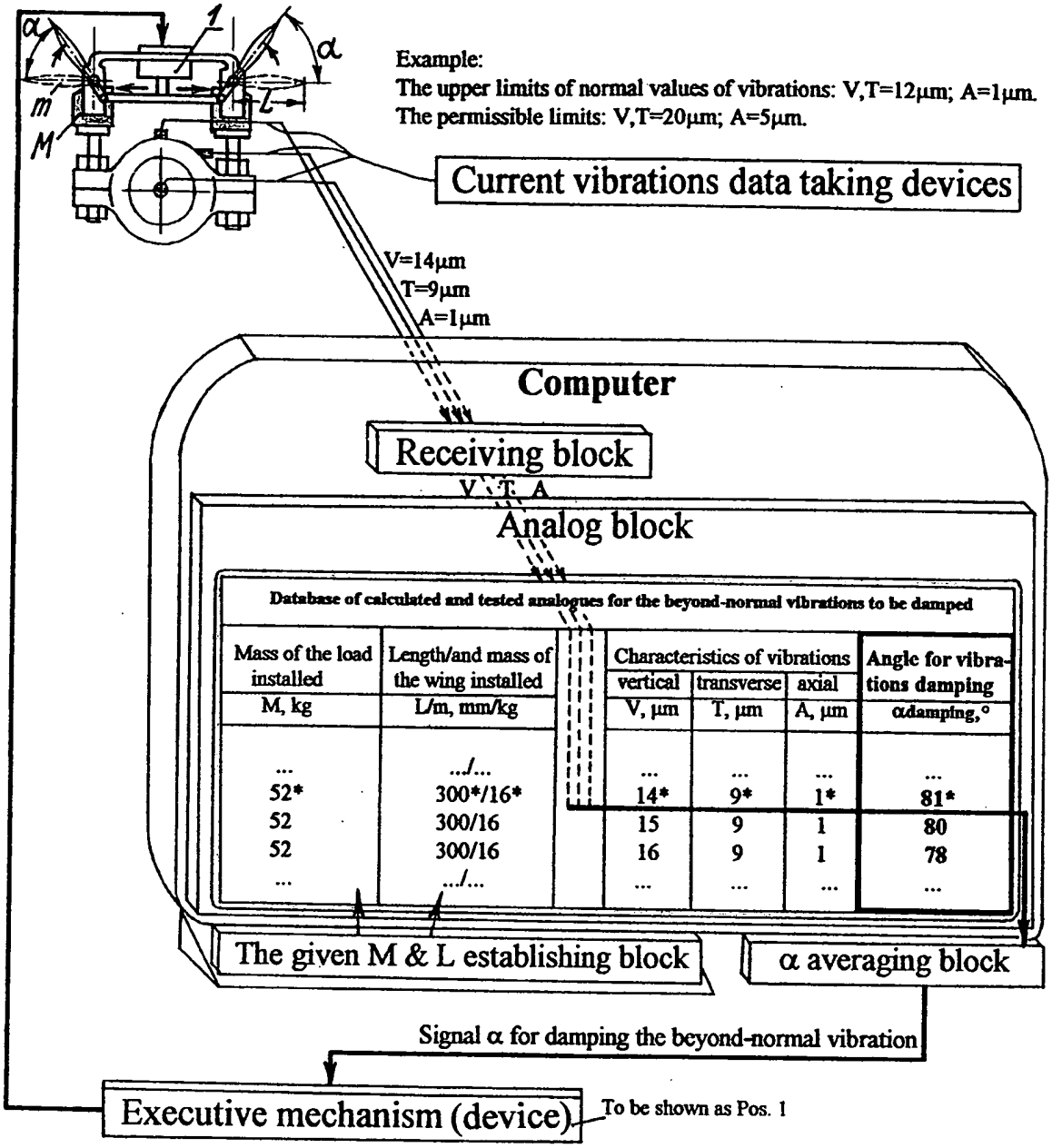
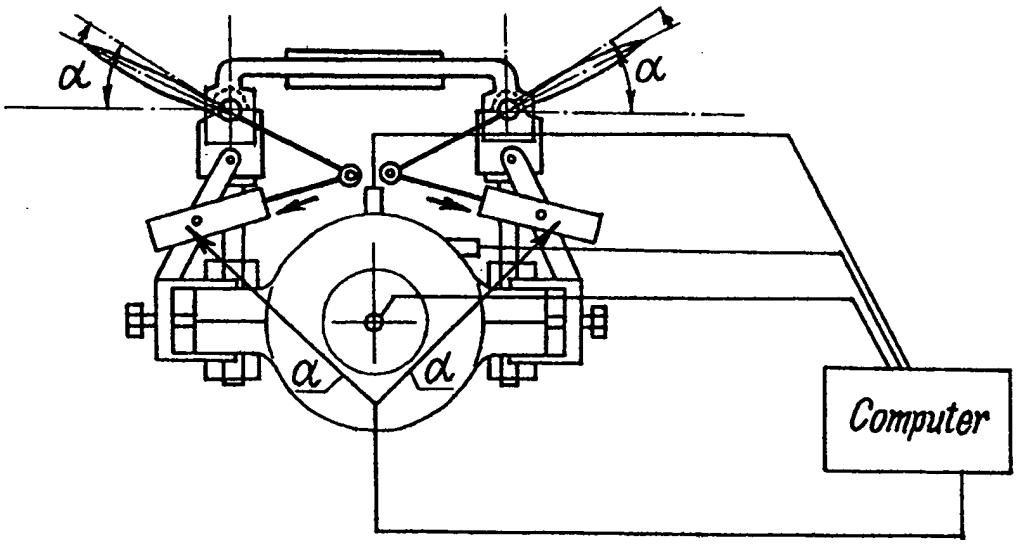
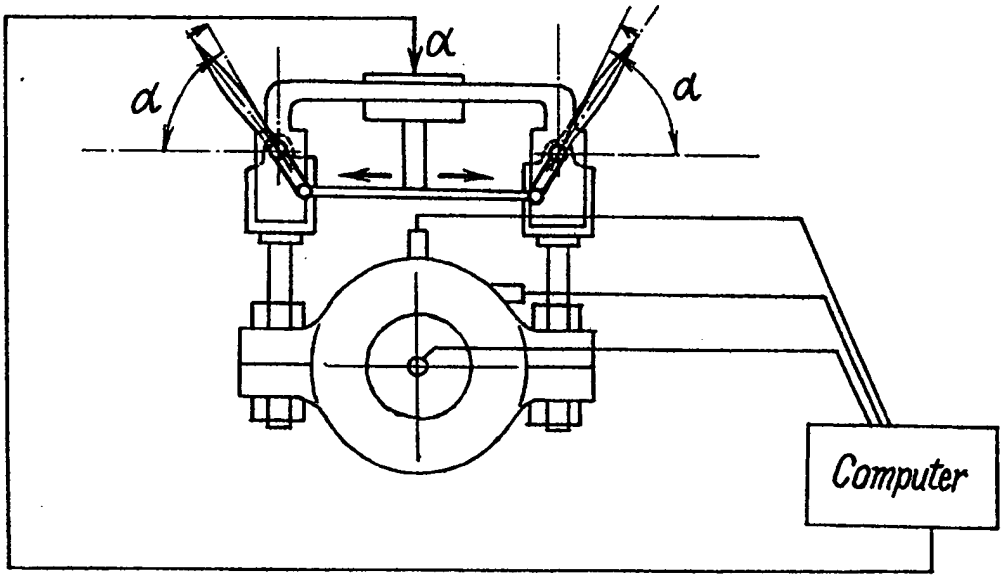


Fig. 29 Automation - - by use a computer and automatic equipment - - of process of removal of beyond-normal vibrations at T-G-Ss. [Wide diapasons.]

* - Here, all the data are shown to serve as illustration only.



Variant I. Bifurcate signal α.



Variant II. Sole signal α.

30

Fig. ~~15~~ Variants of sending signal α.

Variant I: Bifurcate signal sent equally to the two separate executive mechanisms f r turning the wings f the B-F-L-Ws.

Variant II: Sole signal sent to the united executive mechanism f r turning the wings of the B-F-L-Ws.

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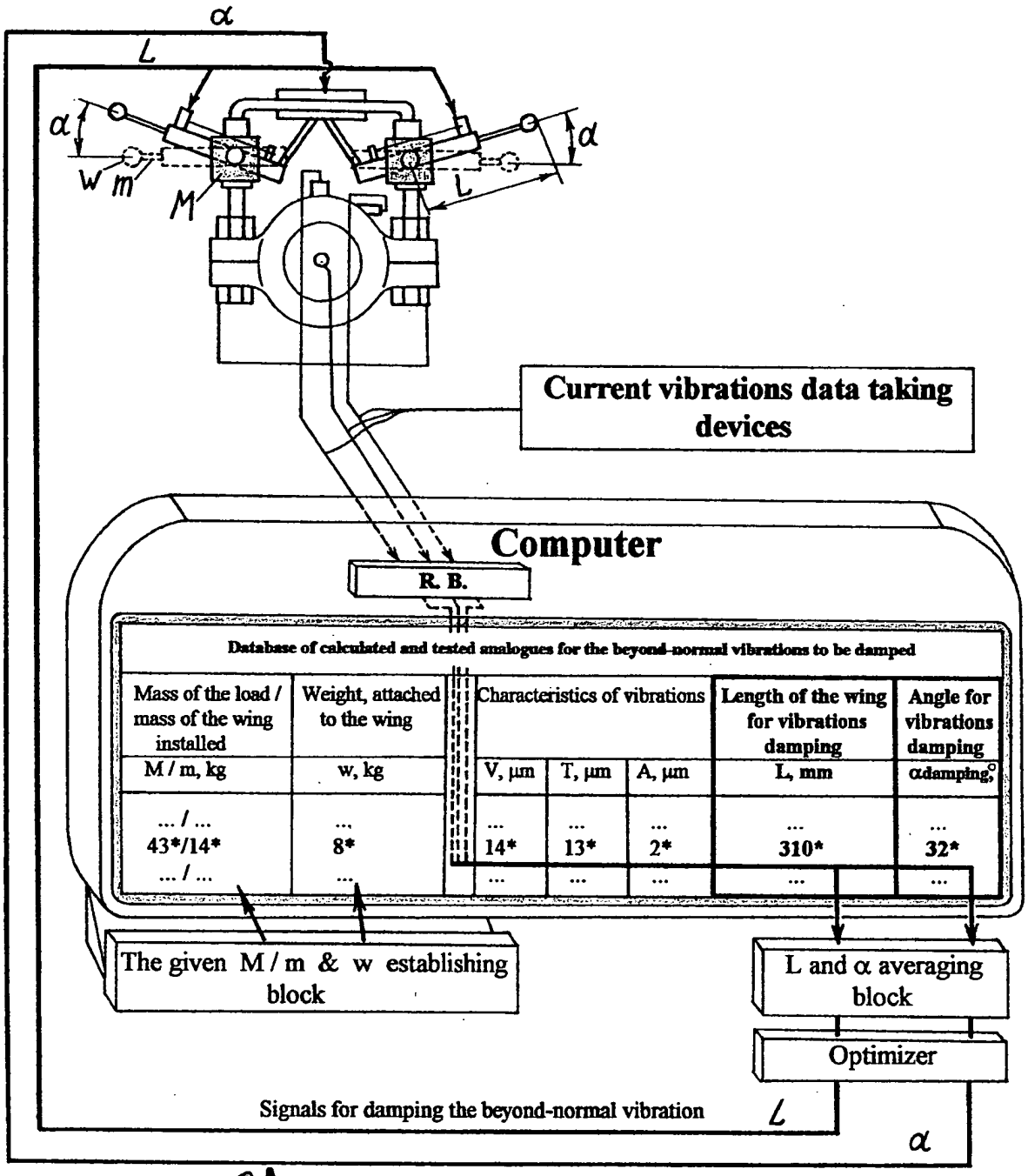


Fig. 12b Automation of process of removal of beyond-normal vibrations at T-G-Ss. [Super-wide diapas ns].

* - Here, all the data are shown to serve as illustration only.

Turbine Generator Vibration Damper System. Vladilen Safonov.

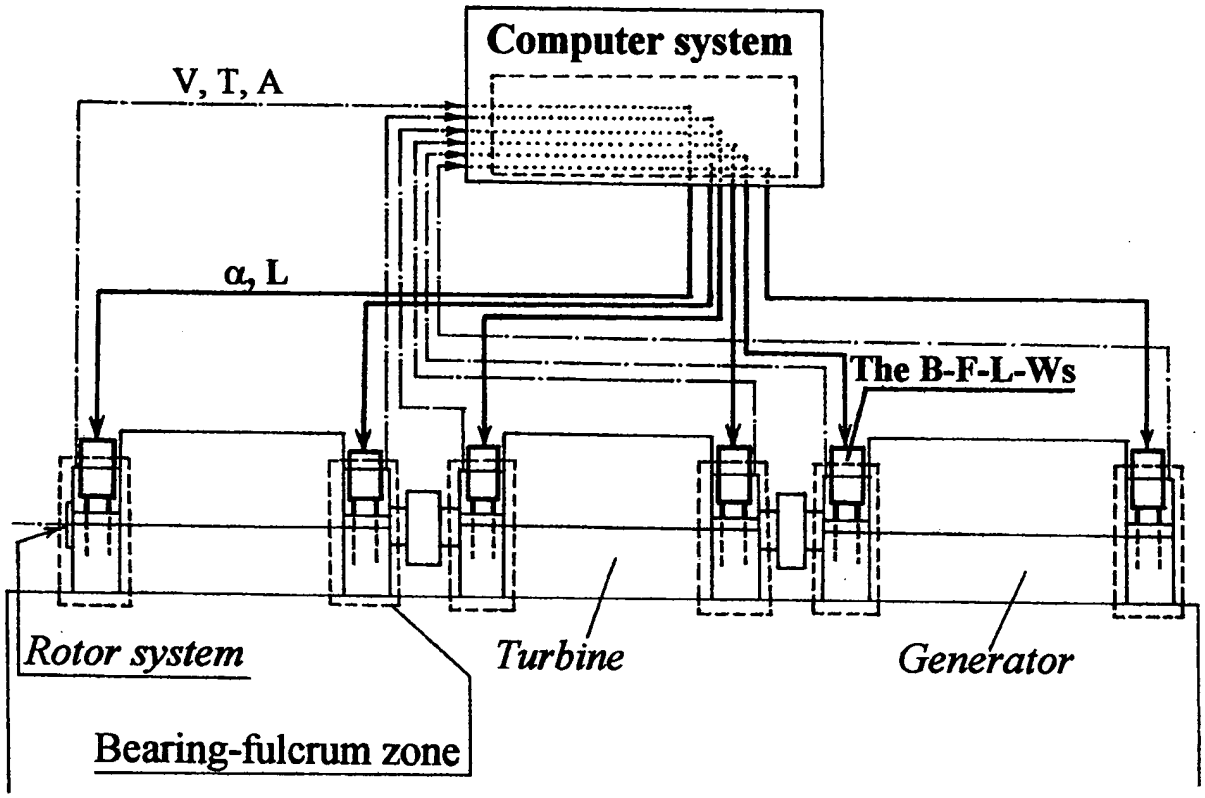
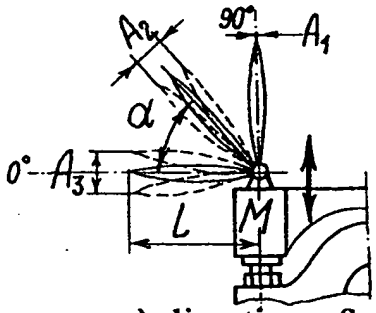
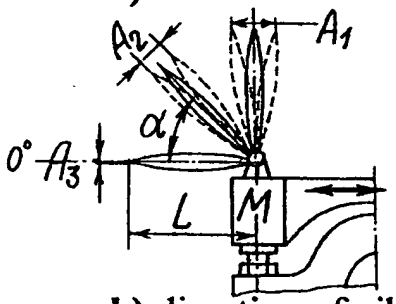


Fig. 32 Automation of process of removal of beyond-normal vibrations and keeping vibration situation normal and stable at whole T-G-S by the use of computer system and automatic equipment.



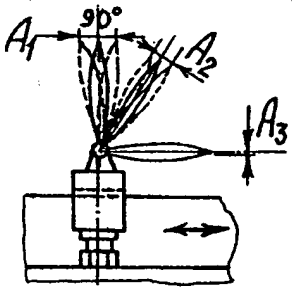
(A3 = Amax)> A2 >(A1 = Amin)

a) direction of vibration: vertical.



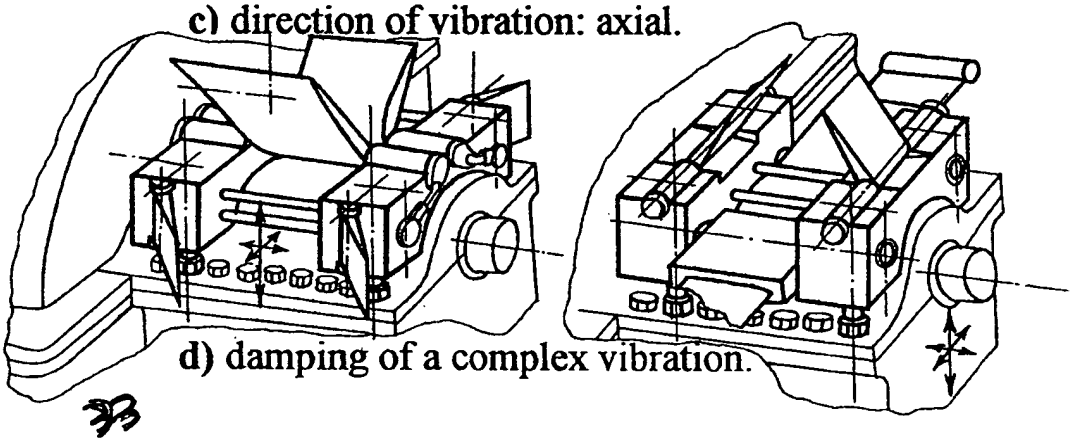
(A3 = Amin)< A2 <(A1 = Amax)

b) direction of vibration: transverse.



0° (A3 = Amin)< A2 <(A1 = Amax)

c) direction of vibration: axial.



d) damping of a complex vibration.

Fig. 33 Simple wings of the B-F-L-Ws.

Work of simple wing for damping vertical [a)], transverse [b)], axial [c)], complex [d)] vibrations within its turn round from 0° to 90°.

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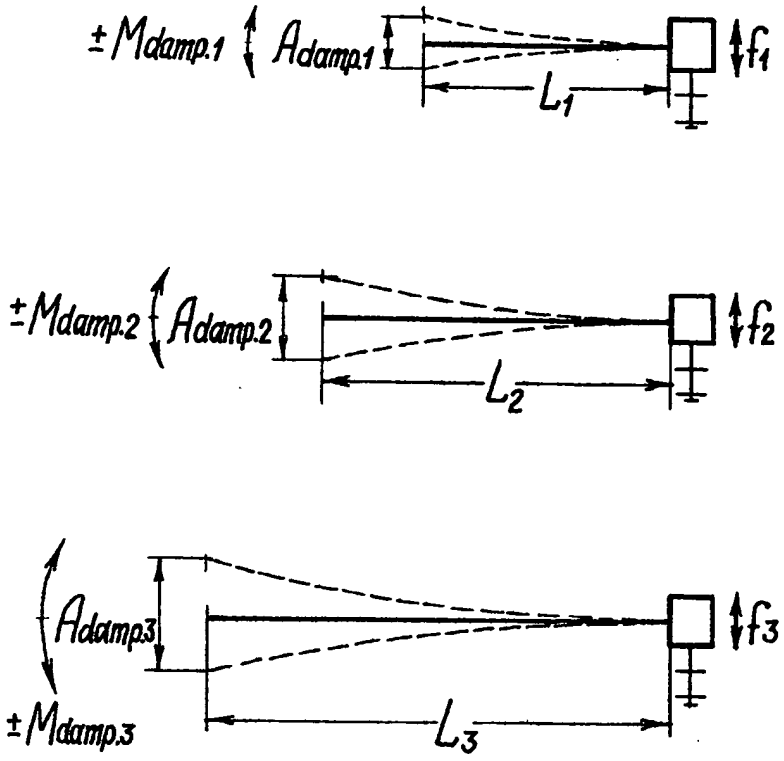

f1 = f2 = f3 .
L3 > L2 > L1 .
+ - Mdamp.3 > + - Mdamp.2 > + - Mdamp.1 .
Adamp.3 > Adamp.2 > Adamp.1 .

Fig. 34 An increase of damping capabilities (in damping momentum Mdamp. and damping amplitude Adamp.) of wing depending on elongati n of its length.

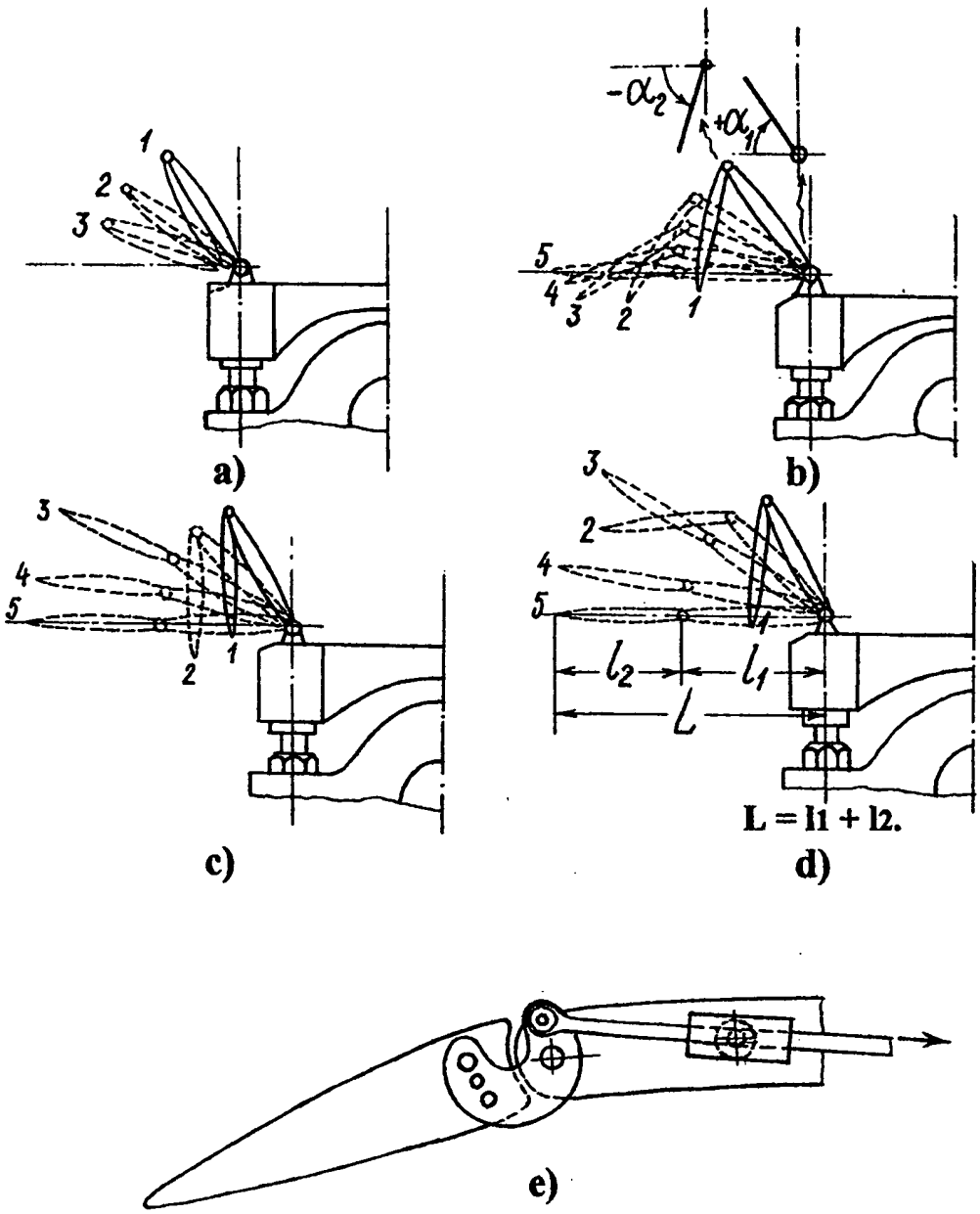

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Fig. 4a Folding wings of the B-F-L-Ws.

Change of damping capabilities of folding wing depending on summary angle ($\alpha 1 + \alpha 2 + ...$) and t tal length of wing ($\overline{l1} + \overline{l2} + ...$).

a), b), c), d) - variants of spreading f lding wings; e) - mechanism for turning the wing (variant).

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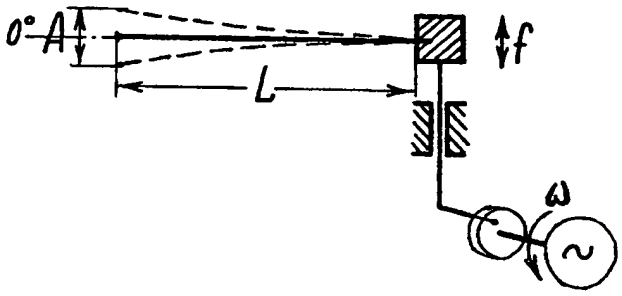
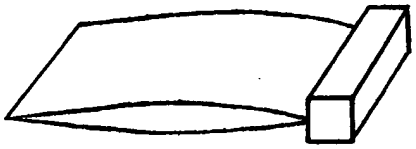
Imitative model



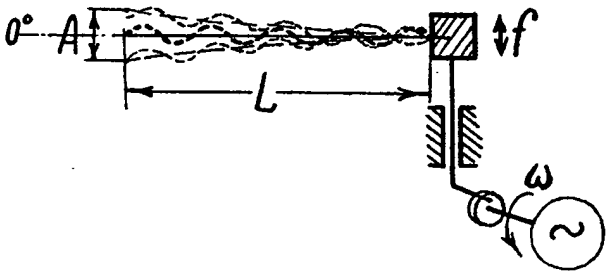
Real model



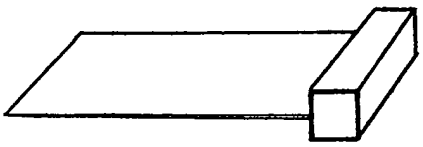
Velocity ω is low, frequency f is low.
Wing is firm, non-flexible / in construction, substance or texture of material /.

a)

Imitative model



Real model

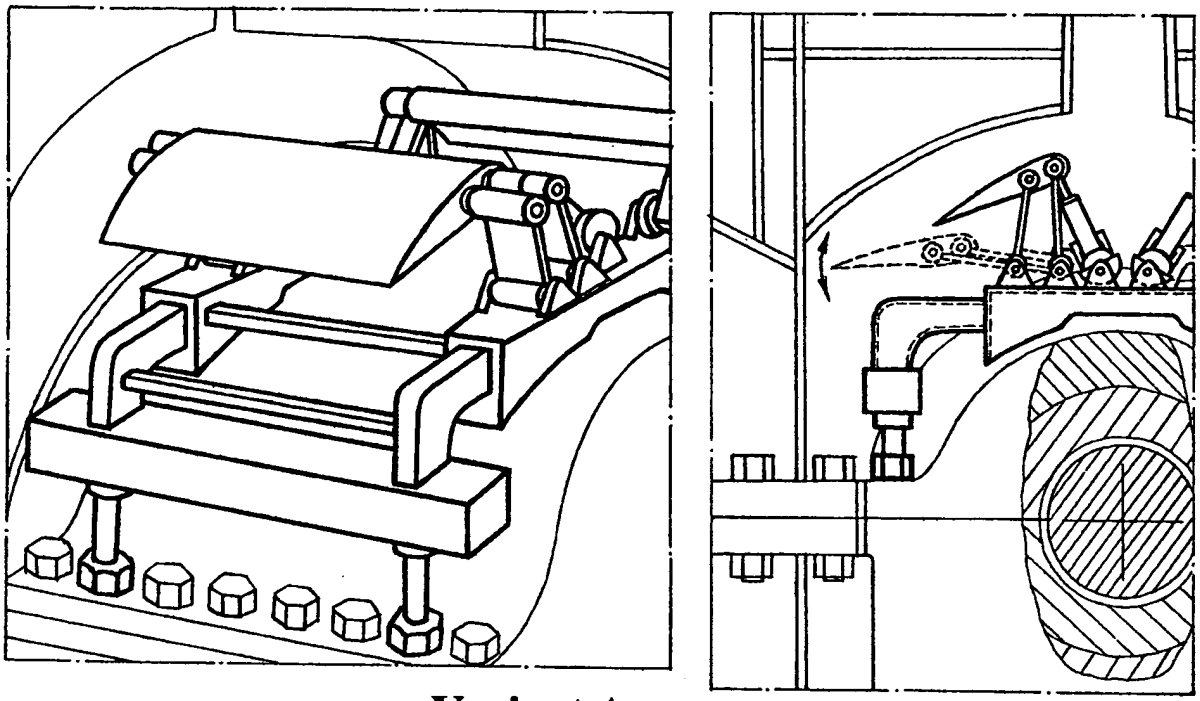


Velocity ω is high, frequency f is high.
Wing is highly elastic, flexible / in construction, substance or texture of material /.

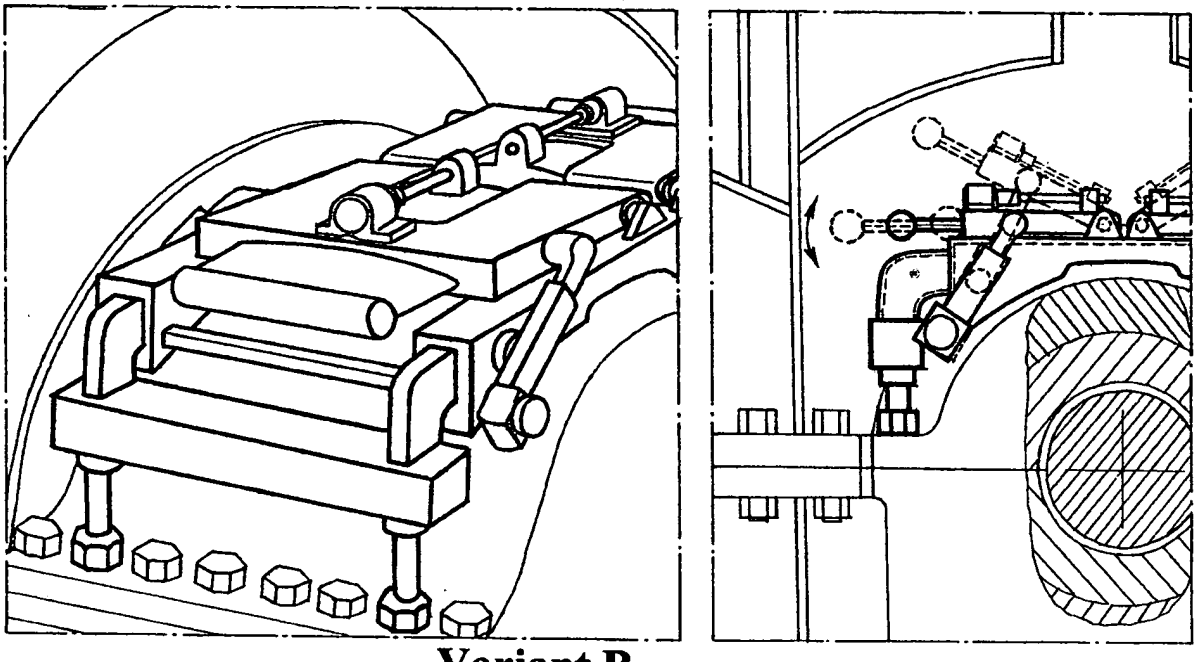
b)

36

Fig. Additional damping capabilities of wing depending on its flexibility.
a) firm wing; b) flexible wing.
(See text in Specification).



Variant A



Variant B

Fig. 37 Some variants of the forms of the B-F-L-Ws adapted t be used at the T-G-Ss' bearings-fulcra with limited space for spreading the wings. See text in Specification.

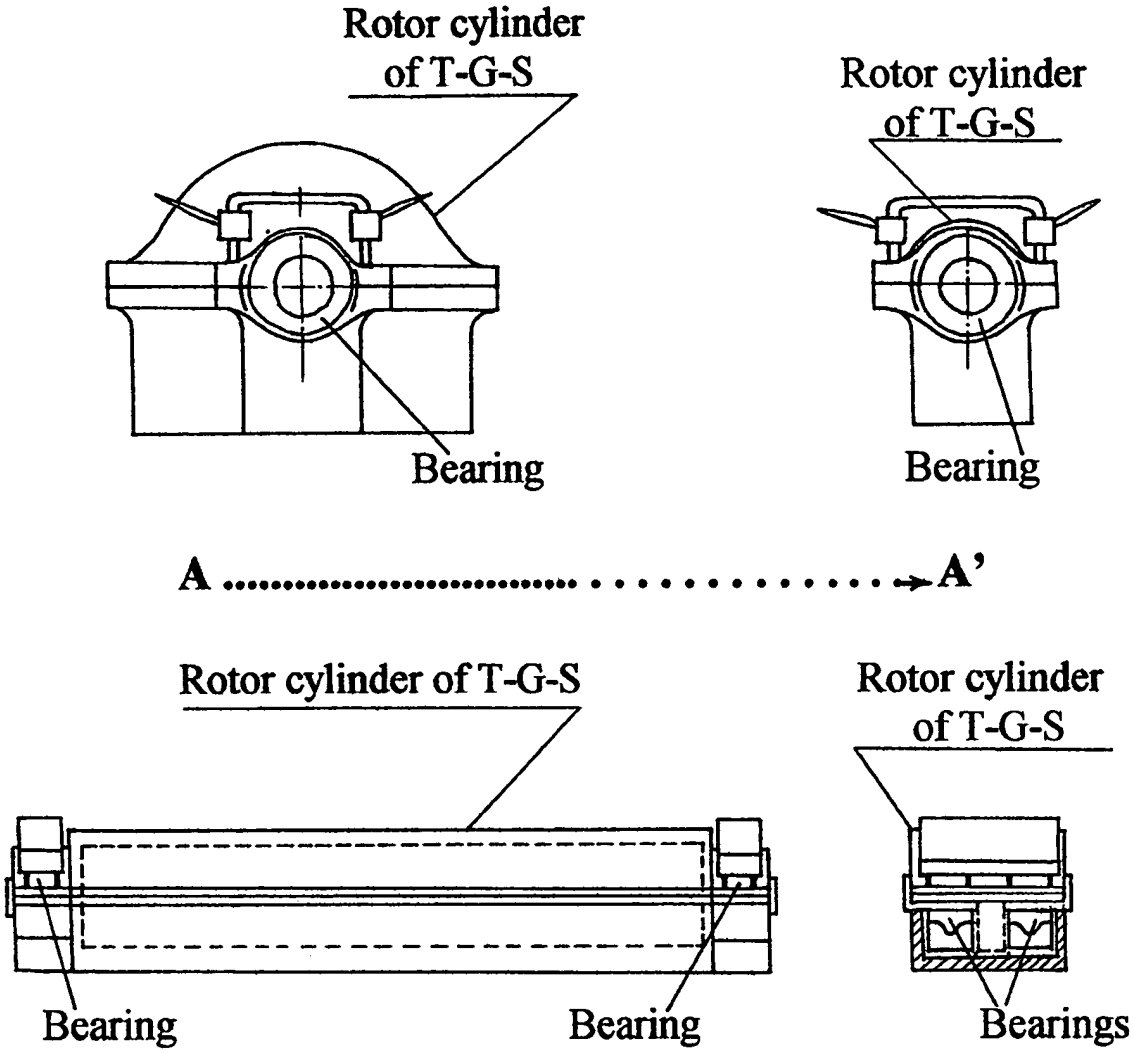


Fig. 17 Correlations A' and B' -- in mutual dimensions and constructions -- between bearings and their related rotor cylinder for which the method of removal of vibrations may be used so, that the B-F-L-Ws will be installed already upon whole rotor cylinder.

Those rotor cylinders are specified- see text in Specification and Limitations.

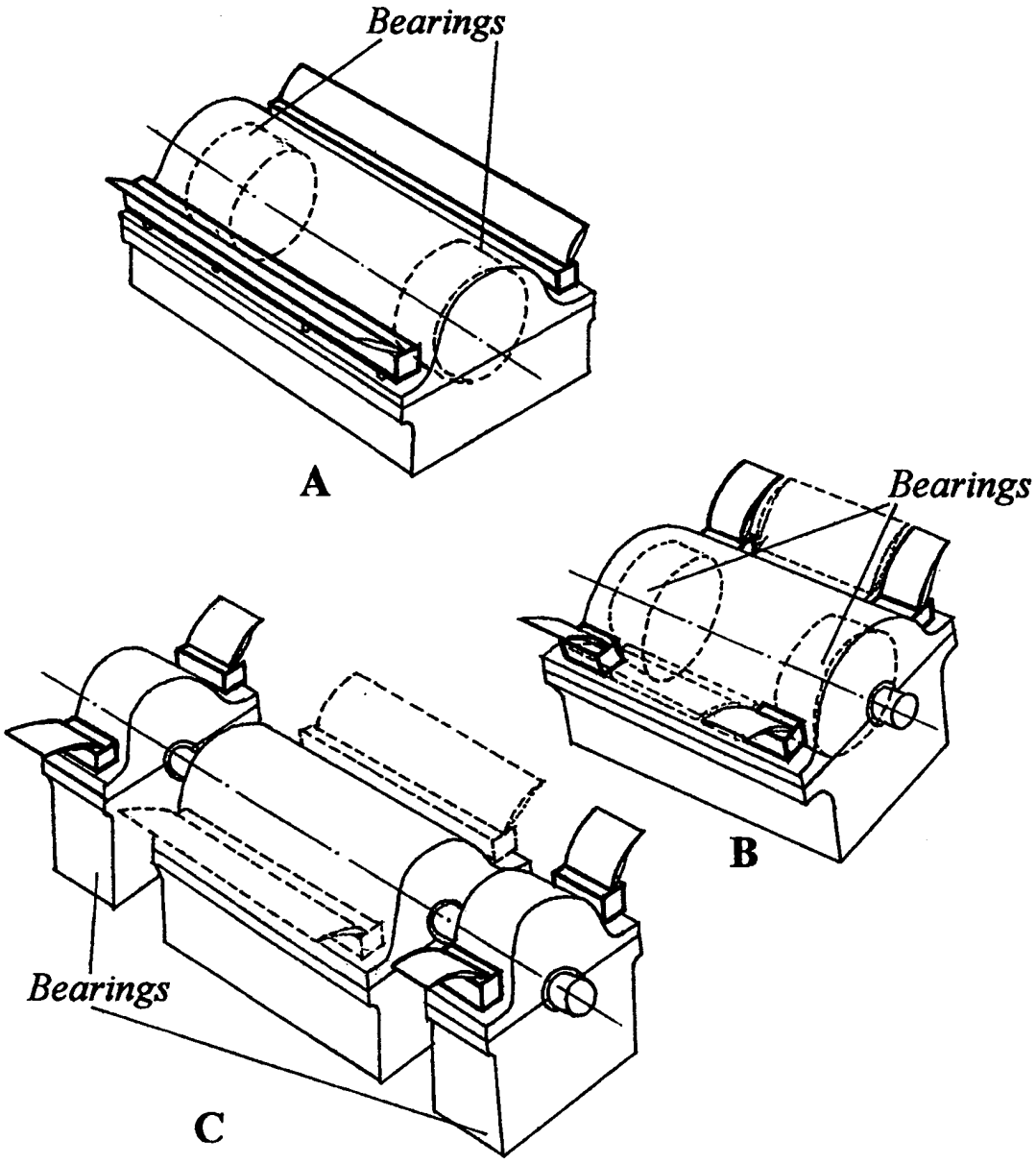


Fig. 18 Variants of installation of the B-F-L-Ws upon the whole rotor cylinders.
See text in Specification and Limitations.

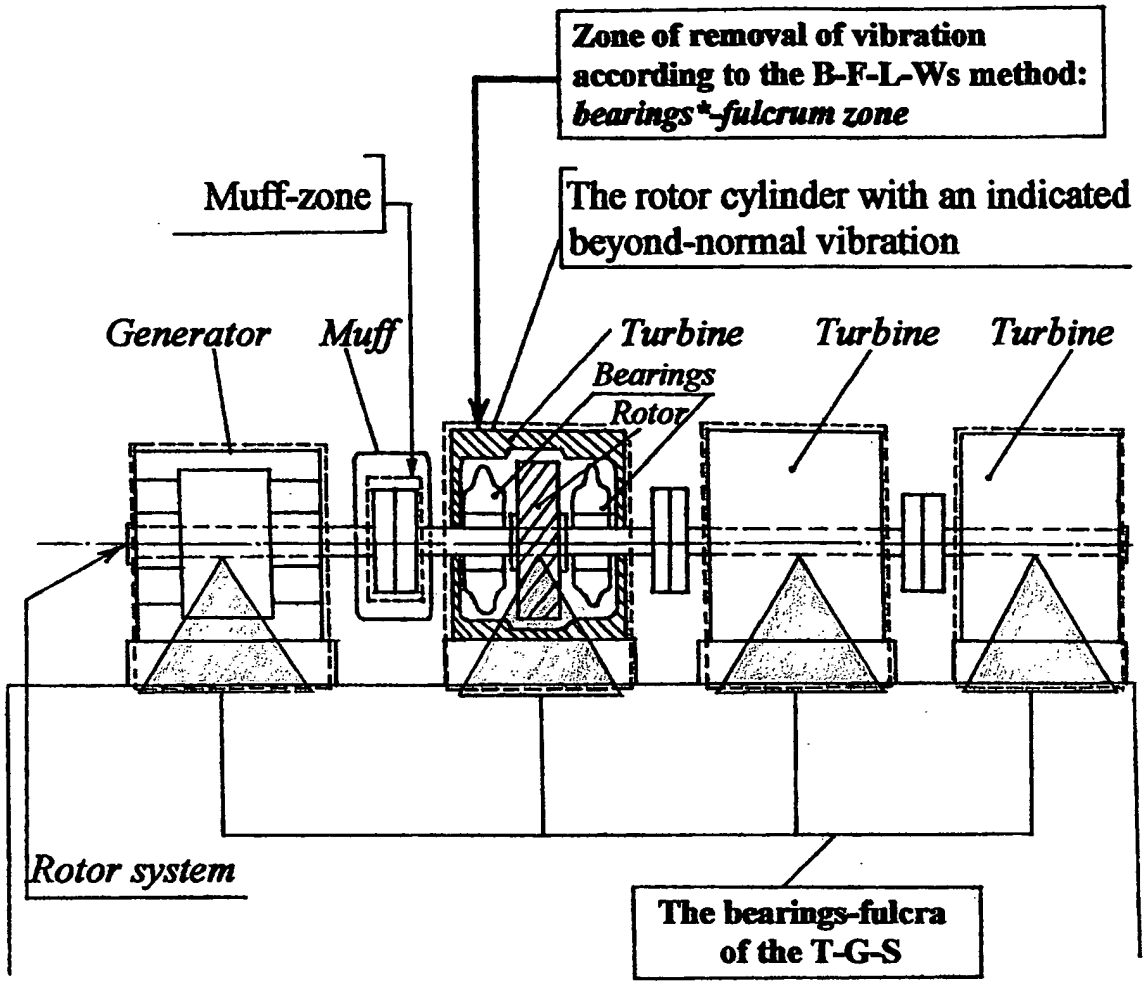


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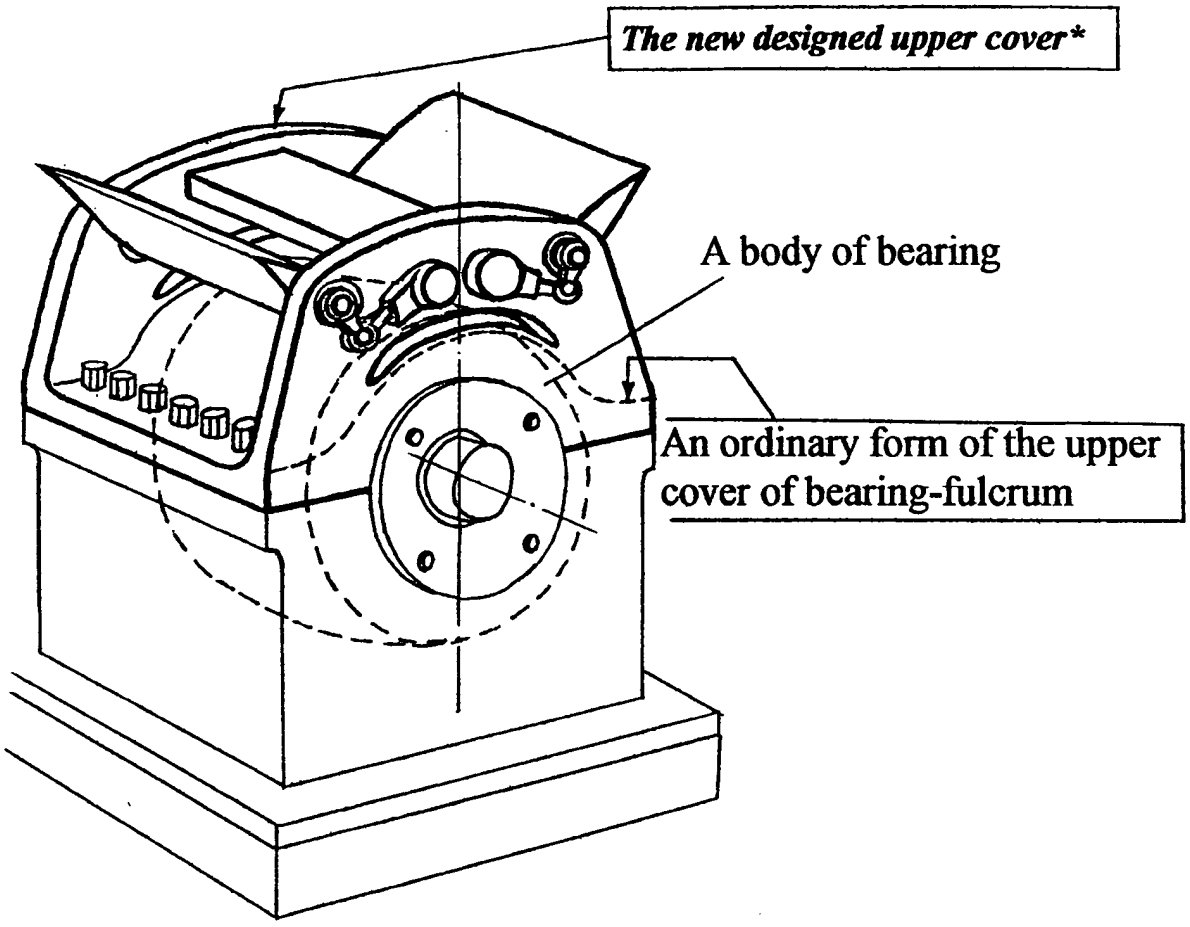
Fig. 19 The specified rotor cylinders of the T-G-S as the fulcra of the whole rotor system.

When the B-F-L-Ws may be used upon whole rotor cylinder and for the corresponding specified rotor cylinders - see text in Specification and Limitations.

Installation of the B-F-L-Ws at the rotor cylinder as a whole, automation of the process of removal of vibrations at every cylinder as a whole and at whole T-G-S, the limitations are analogic to what must be done for the B-F-L-Ws to be installed and used at bearing-fulcrum.

*** - *bearings-fulcrum zone* - compare with *bearing-fulcrum zone* (see Fig. 1).**



A

Bearing-fulcrum of T-G-S

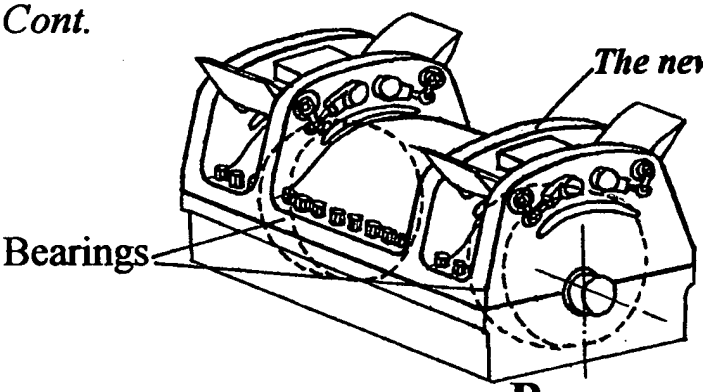
41

Cont.

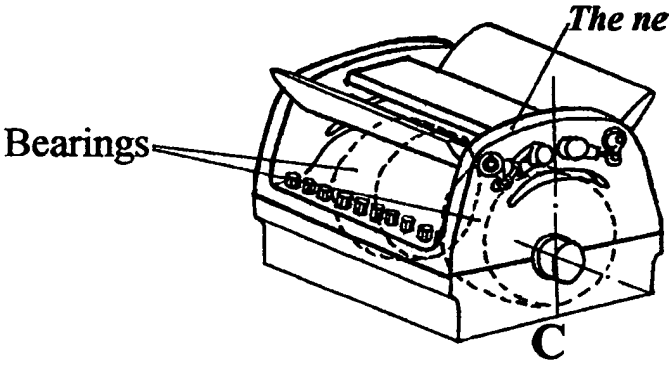
Fig. 20 Variants of simple changings of the construction of bearing-fulcrum (or the form of its upper cover) in the future designed T-G-Ss to be adapted for use of the B-F-L-Ws method - removal of vibrations at T-G-Ss without stopping their generating electricity / being in operation.

**** - The additional mass (including loads-wings and related units) that will be added to the ordinary mass of upper cover has to be equal to a double mass of the single bearing-fulcrum-load-wing (B-F-L-W).***

Cont.



The specified rotor cylinder of T-G-S



The specified rotor cylinder of T-G-S

41

Fig. 20 ***Continuation.*** **Variants of simple changings of the construction of bearings-fulcrum (or the form of its upper cover) in the future designed T-G-Ss to be adapted for use of the B-F-L-Ws method - removal of vibrations without stopping their generating electricity / being in operation.**

***** - The additional mass (including loads-wings and related units) that will be added to the ordinary mass of upper cover has to be equal to two double masses of the single bearing-fulcrum-load-wing (B-F-L-W).***

****** - The minimal additional mass that will be added to the ordinary mass of upper cover has to be equal to two double masses of the single bearings-fulcrum--load-wing (B-F-L-W).***

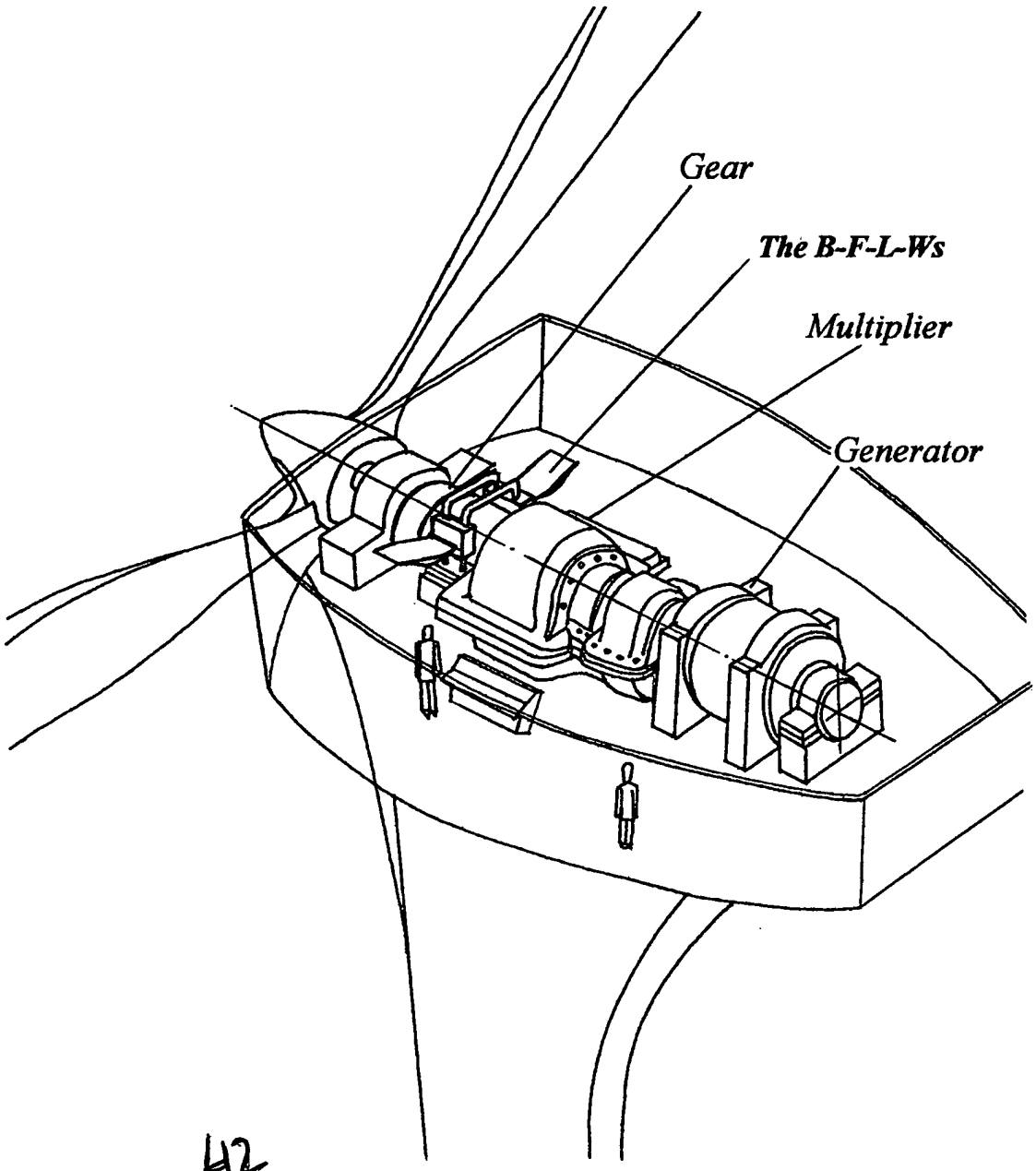


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Fig. 42 Removal of vibrations with the B-F-L-Ws at bearing-fulcrum of T-G-S.
Wind Electro Power Plant.
General view.

Turbine Generator Vibration Damper System. Vladilen Safonov.

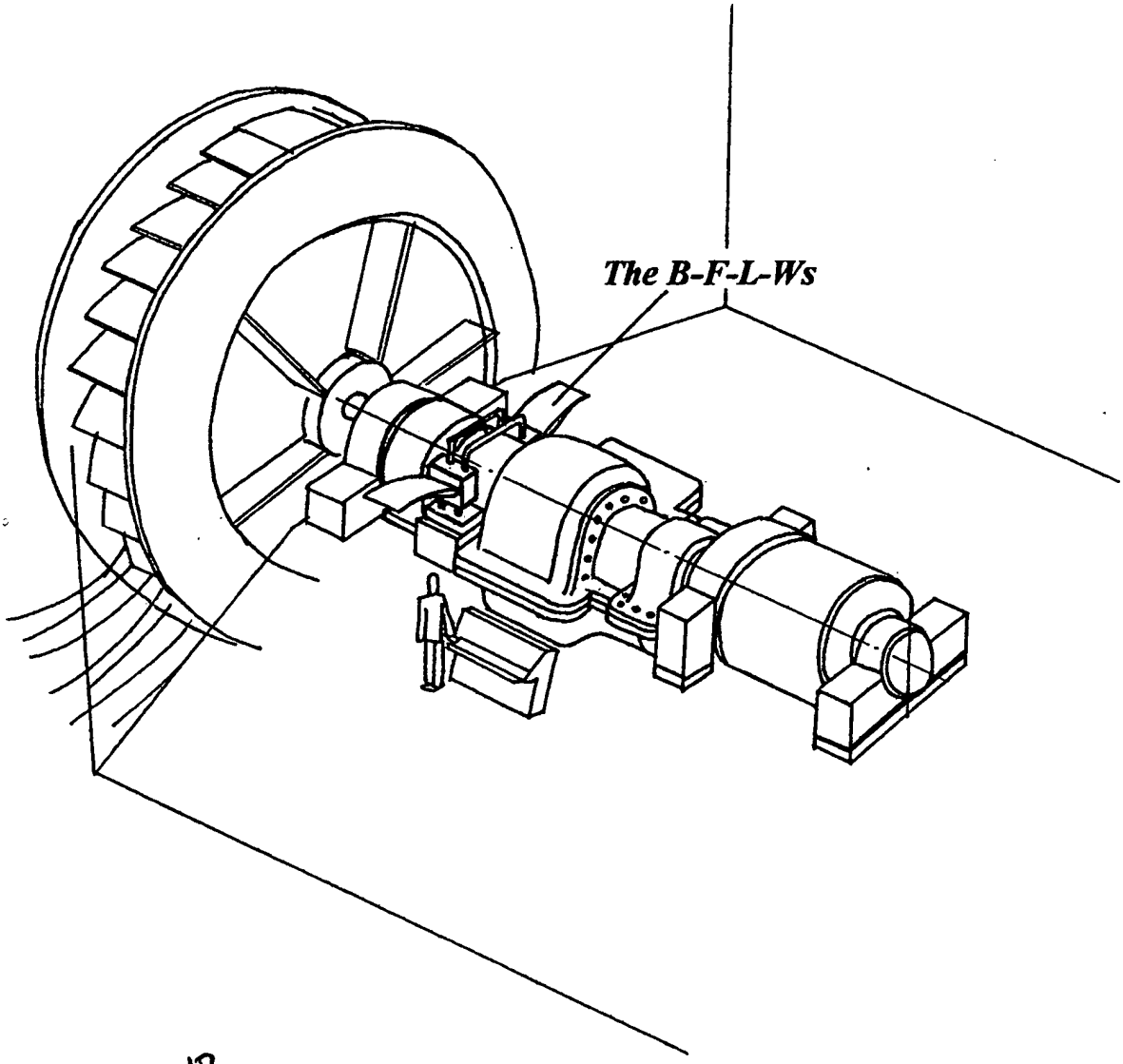

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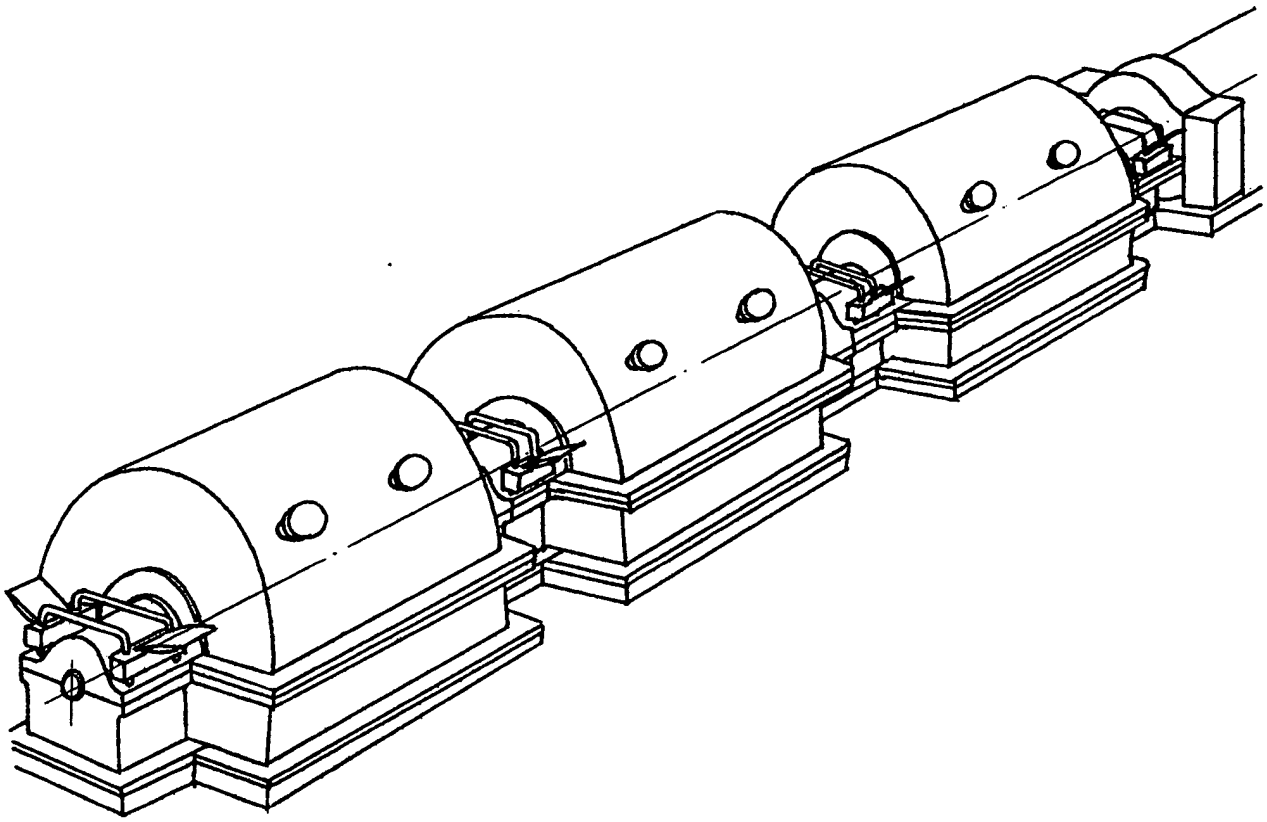
Fig. 22 Removal of vibrations with the B-F-L-Ws at bearing-fulcrum of T-G-S.
Hydro Electro Power Plant.
General view.

Turbine Generator Vibration Damper System. Vladilen Safonov.



44

Fig. 23 Removal of vibrations with the B-F-L-Ws at whole T-G-S.
Electro Power Plant.
General view.